CONVENTIONAL SOCIAL BEHAVIOUR AMONGST MICROFINANCE CLIENTS

P. LUCAS

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PABLO LUCAS

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Conventional social behaviour amongst microfinance clients

by
Pablo Lucas

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Manchester Metropolitan University
Business School, Centre for Policy Modelling

I hereby declare that research presented in this thesis was done only by myself at the Centre For Policy Modelling, Manchester Metropolitan University, except where due acknowledgement is made and has not been submitted to any another degree.

Pablo Lucas

Supervisors: Bruce Edmonds, Scott Moss

28th February 2014

Date

Dedicated to Wasyl and Jadwiga Zawalski.

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Abstract

This doctoral thesis inductively explores the role of conventional social behaviour adopted by individual microfinance clients regarding their influence over their own collective success as a microcredit group. The collective credit in question is subject to an adaptation in Mexico of the Grameen Bank lending framework. An analysis is made on the close interplay between institutional rules, i.e. the repayment conditions imposed by the microfinance institution (henceforth MFI), and the emergent cooperation and penalisation mechanisms that are handled by clients themselves to meet their targets. Thus the research is focused on the clients' strategies to socially manage debt and defaulters.

In this case study, a socio-economical fieldwork has been completed through surveying 600 microcredit clients, their 2404 active loans, 35 credit officers plus their board of directors. This took place in the southernmost state of Mexico, Chiapas, from September 2007 to February 2008, and data analysis was carried out during that period until July 2009. All findings were discussed with relevant stakeholders and policy makers. This proved key in providing influential insights that helped to improve the institutional regulatory framework. That resulted in a policy change that benefited over 20,000 clients. Apart from institutional regulations, it has also been observed group-level strategies devised by microfinance clients themselves to assess and deal with defaulters over time. These operate independently from the MFI framework as, despite influencing when and how quotas should be repaid, their criteria is entirely dealt with and evolved within credit groups. The obtained outcomes from analysing social and financial data include:

- (I) insights backed by empirical data helped to influence an adaptation of the MFI funding credit policy, so that group structure and conventions are actually taken into consideration in a bid to foster more successful microcredit groups;

- and (II) an analysis deemed reliable by the stakeholders for policy-making purposes, which has also guided the development of an exploratory model for simulating behaviour of how microcredit groups may deal with repayments in adversity.

As a result of having developed this research project, three contributions to knowledge are discussed in the thesis. These are organised below according to relevant topics.

1. Understanding the behaviour within studied microfinance groups: based on the analysed evidence, a hypotheses is suggested about how group location and membership can influence the dynamics of acceptable behaviour regarding defaulters.

2. Informing policy-making with research findings: a demonstration of how stakeholders can assess the usefulness of knowledge –produced via research– for policy-making purposes, taking into account the phenomenon's particular context.

3. The development of an agent-based model (henceforth ABM): application of the proposed ABM methodology, aimed at strengthening validation throughout the modelling process with emphasis on use of evidence and stakeholder participation.

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Chapter 1

Introduction

This doctoral thesis considers the roles of conventional social behaviour, i.e. informally expected behaviour according to the participants, amongst microfinance clients with regards to maintaining successful financed groups. The case study in this research project is a microfinance institution (henceforth MFI) operating in Chiapas, which is the southernmost Mexican state –and consistently has been one of the poorest since 1970 [Biggar, 2009, Chiquiar, 2005, Yoshioka, 2006]. There the MFI has adapted the pioneer Grameen Bank group lending framework in 1999 to suit their local circumstances[1].

One key aspect, and perhaps the most discussed, for the success of the MFI scheme is the condition in which credit instalments can be granted without needing conventional collateral [Brau and Woller, 2004, Ledgerwood, 2001]. That means none of the traditional property, for example in the form of financial assets, are required to backup collective credit applications. Instead a criterion based on the concept of *social collateral* and poverty lines are used by MFIs as the main evaluators as to whether the institution should collectively fund small-scale entrepreneurs. The idea is that the burden of repaying credit quotas on time in this framework becomes a collective responsibility, through the harnessing of social pressure and trust between all the group members as a way to stimulate productive economic activities. However this has been little researched as to how these social pressures work.

[1] *Nota bene:* due to the sensitive data, the MFI required omission of their precise identity and location of operations as a condition to allow the publication of the research findings.

Despite worldwide success of the microcredit framework, which has been consolidated since the 1970s by Muhammad Yunus leading the Grameen Bank initiative in Bangladesh, there is still a need for more in-depth understanding of how group members deal with defaulters and honour their outstanding debts in time. This doctoral research is focused on the interplay between bottom-up, behavioural conventions and top-down, institutional rules governing the MFI policies. The discussion presented in this thesis is based on the analysis of data collected from credit officers and their groups of clients.

1.1 Objectives and Contributions to Knowledge

The broad goal of this project is to further understand and explore the emergence of conventional social behaviour amongst microfinance clients. The case study for this thesis is a mid-sized MFI (slightly over 20,000 clients) in southern Mexico. This research provides a contribution to understanding, in greater detail, the social structure and supporting mechanisms within microcredit groups for dealing with institutional rules governing collective credit. The specific objectives of this research are the:

- analysis of financial and behavioural data collected from 600 microcredit clients, which also includes the institution board of directors and their 35 credit officers;

- development of an agent-based (simulation) model (henceforth ABM), guided by the findings and insights obtained by analysing the stakeholders' collected data;

- evaluation as to which research findings, yielded from the process of analysing the collected data and developing the ABM, were useful for policy-making by the MFI.

The three aforementioned objectives, along with publications and visits to other academic institutions, helped the development of the following contributions to knowledge:

1. understanding the behaviour within studied microfinance groups, based on the analysed evidence, with a suggestion about how group location and membership can influence the dynamics of acceptable social behaviour regarding defaulters[2];

2. a demonstration of how stakeholders can assess the usefulness of knowledge – produced via research– for policy-making purposes, taking into account the phenomenon's particular social context and socio-economic characteristics;

3. refinement and application of an ABM development methodology, originally put forward in this thesis, aimed at strengthening validation throughout the modelling process with emphasis on use of evidence and stakeholder participation.

1.2 Organisation of this Doctoral Thesis

In order to facilitate understanding how each subsection inform and is related to other ones in the thesis, a diagram based on the table of contents is provided in Figure 1.1 on the next page. Chapters and sections are coloured according to the following schema:

- (a) blue indicate the discussion of constructs used to develop the contributions;
- (b) cyan present how the research design has been proposed and carried out;
- and (c) green contain the findings obtained based on the relevant chapters.

[2] This data has been gathered through surveys and complemented with ethnographic fieldwork observations leading to two suggestions. These are discussed in greater detail in chapters 5: "Research Findings" (page 100) and 6: "Final Discussions and Conclusions" (page 165).

The arrows in the diagram indicate how each part of the thesis inform the development of the next section and, thus, also suggest a logical approach to understand the thesis.

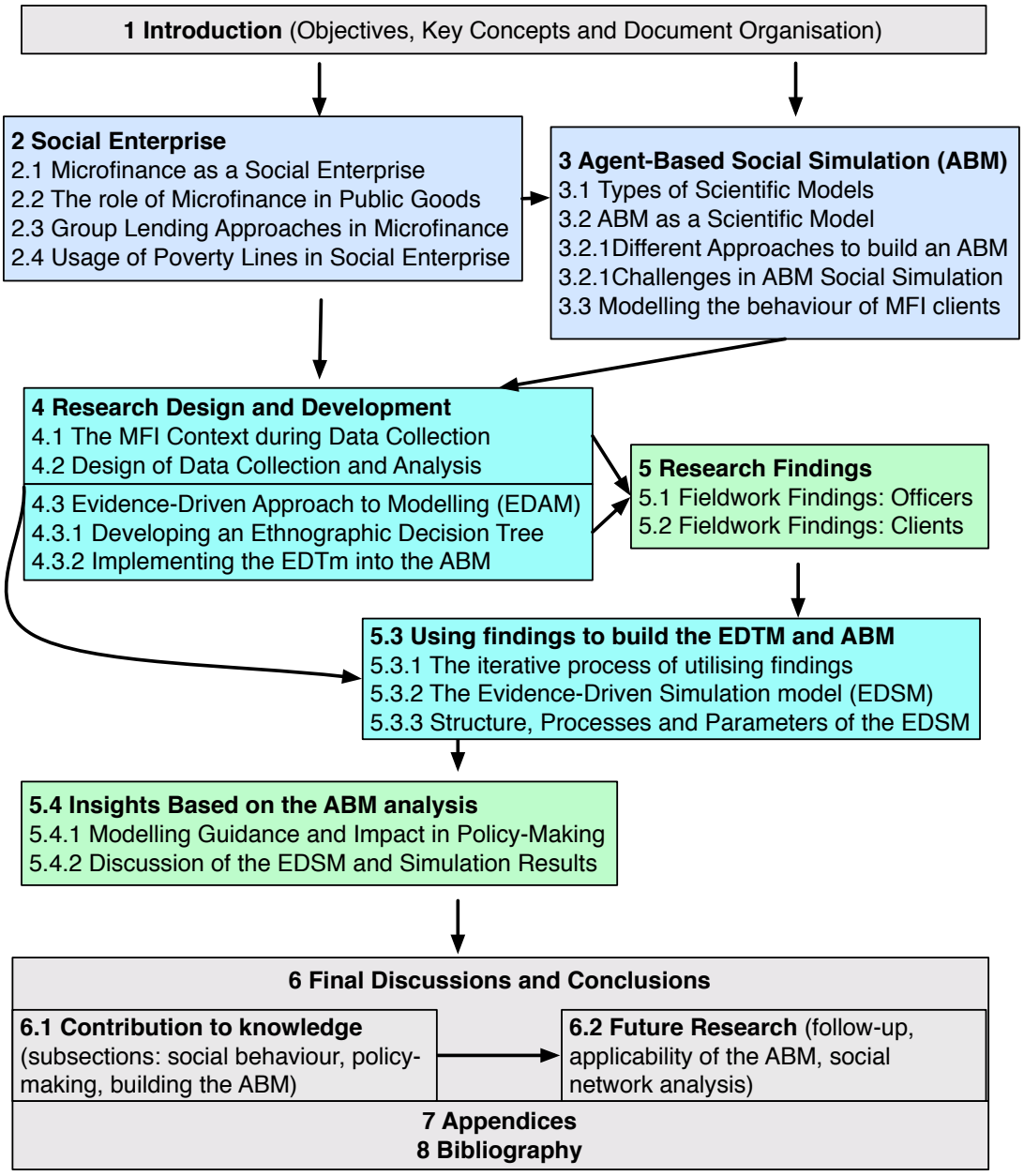


Figure 1.1: Diagram depicting the thesis organisation

The twined relationship between the two main topics is discussed in the chapters marked in blue. Each is key to inform the research problem and how it has been tackled with the proposed research design. Chapter 2: "Social Enterprise" (page 17) contain key discussions that substantiate the understanding of relevant open issues in microfinance.

In Chapter 3: "Agent-Based Social Simulation" (page 48), the relevant aspects of the state-of-the-art in ABM are discussed and an in-depth development life cycle is proposed within sub-section 4.3: "Evidence-Driven Approach to Modelling (EDAM)".

Chapter 4: "Research Design and Development" (page 75) contains a detailed discussion of the research design. It covers the cross-sectional structure of the surveys, the randomisation procedures to minimise biases in selecting credit clients and a discussion of the relevant behavioural findings that are then contextualised with financial data.

Chapter 5: "Research Findings" (page 100) presents two discussions based on the results obtained via the research design and data analysis that has been duly carried out:

- Section 5.1: "Fieldwork Findings: Credit Officers" (page 101) and Section 5.2: "Fieldwork Findings: Microfinance Clients" (page 114), focused on the surveys that have been administered to all the stakeholders involved in the case study;

- Section 5.3.2: "The Evidence-Driven Simulation Model (EDSM)" (page 132), which is focused on the agent-based model that has been developed and then the discussion moves onto Section 5.4: "Insights Based on the ABM analysis".

The last chapter, 6: "Final Discussions and Conclusions" (page 165), sums up the critique regarding difficulties, achievements and promising future research ideas. Should the reader wish to access additional information about the discussed topics, the appendices can be found from page 175 onwards. The last section contains all the references used in the thesis.

1.3 Research Problem and Research Questions

The aim of this research is to understand in greater detail how and when social behaviour influences both micro (individual) and macro (collective) dynamics within microcredit groups, using the state of Chiapas in Mexico as the specific case study. Given the specific nature of behaviour within microfinance groups, and the lack of empirical analysis of actual coping individual behaviour that deal with defaulters, new data has been collected and analysed according to the research design discussed in Chapter 4: "Research Design and Development" (page 75) in order to address the questions below.

The research problem consists thus of empirically investigating the behaviour, within microfinance groups, that enables members to cope with defaulters. For this, two sets of research questions have been generated. The first set is about credit officers and these are addressed in detail in Section 5.1: "Fieldwork Findings: Credit Officers" (page 101):

1. What is understood by support, moral and ethics within microcredit groups?
2. What is seen as advantages and disadvantages of their microcredit framework?
3. What are the observed clients' actions regarding missed meetings and payments?

The second set of research questions, regarding the credit clients, are addressed in detail in Section 5.2: "Fieldwork Findings: Microfinance Clients" (page 114):

4. What is the composition of their business and advice networks?
5. What are the statuses of their group composition and credit?
6. What are their typical actions regarding missed meetings and payments?

The methodological research question addressed in this thesis is: how can one explore, under different adverse conditions, the role of individual behaviour within the collective responsibility imposed by a microcredit group? This has been done by developing an ABM [3] using the evidence analysed that addresses the aforementioned research questions.

[3] Discussed in Section 5.3.2: "The Evidence-Driven Simulation Model (EDSM)" (page 132).

Chapter 2

Social Enterprise

"This is business with a social objective, which is to help people get out of poverty."

Muhammad Yunus, 2009

This chapter contains key discussions to understand how MFIs can be assessed as Social Enterprises (SEs) and which gaps can be tackled in the under-provision of public goods through microfi-nance. For that it is necessary to be acquainted with the different settings a MFI can operate, the levels in which the organisation progress plus the tools and concepts that facilitate these analyses. The chapter also highlights the need to design research to inductively explore the behaviour dynamics in microcredit groups. The table of contents (henceforth TOC) is below and the next paragraph provides the first key definition.

The term Social Enterprise (henceforth SE) can be defined as an organisation that seeks to achieve social aims via entrepreneurial (economic) activities, without an intention to supplant governmental or private organisations [EMES and UNDP, 2006]. Thus this can include cooperatives, credit associations, foundations, charities and any other entity that locally provide –or contribute– to a collective benefit (product or services).

Contents

2.1 Microfinance as a Social Enterprise

The quote by one of the microfinance pioneers, on the previous page, concisely encapsulates the main objective that is embedded in the overall mission and definition of a SE. I.e. to pursue a business model that channels most of its profits into solutions to either socio-economic or socio-environmental adversities. These, in turn, are often partially due to inadequate provision of public goods. This includes a wide range of productive and redistributive institutions, which can be diversely structured as: foundations, not-for-profit, non-governmental organisations (henceforth NGOs) and the public sector. Examples of that include the cooperatives, credit unions, charities, voluntary organisations such as charities and MFIs [Austin and Chu, 2006]. This implies that the backdrop of SEs must encompass their own awareness of having an impact in terms of promoting social cohesion and/or mitigating poverty, a concept which has substantially different connotations in developed and developing economies[1]. In short, a SE is generally focused on creating new market opportunities to develop a social agenda.

The impact of harnessing the entrepreneurship facilitated by SEs has been witnessed, throughout the world, in a wide range of innovative public good matters. This includes, for example: health provision (e.g. nutrition, disease prevention and treatment), governance (e.g. the evaluation and adaptation of sustainable policies), education (e.g. general and financial literacy), employment (e.g. creation of jobs and access to banking services) [Alter, 2002, DTIUK, 2002, Davister et al., 2004, Borzaga et al., 2008a]. Given the variety of SEs institutional settings and on-the-ground contexts, their efficacy and efficiency are typically vulnerable from a number of perspectives. Each of them include various components, yet all of these depend –to a greater or lesser extent– on the local political and economical *status quo* in which a SE is operating. Such complex circumstances affect the most those SEs that operate within (a) very limited financial autonomy and/or (b) have to cope with overly restrictive political regimes, as then their access to services in the public or private sector may be impaired [EMES and UNDP, 2006].

[1] In terms of using absolute poverty and relative poverty lines, nationally and internationally.

The former issue is linked with the eminent impossibility of SEs becoming fully self-sufficient in economic terms, whilst the latter issue is about SEs having to deal with excessively centralised –and often corrupt– politicians and/or civic institutions [Townsend, 2006, United Nations, 2006, 2010, UNITAR, 2013]. These difficulties highlight the need to employ effective models of interaction between stakeholders, researchers and policy-makers. Such approach can help to safeguard against the risk of SEs developing chronic inefficiencies that may ultimately lead them towards to becoming wholly unfit for their own original purposes of mitigating poverty. In this sense, an in-depth understanding (both qualitative and quantitative) of the societal problems targeted by a SE is essential to appropriately design and assess their expected and actual socio-economic impact. One can therefore generally understand a SE as an organisation that is developed either by an individual or a group of social entrepreneurs, which may be directly supported by governmental policies. Thus every MFI is a potential innovative provider of, or contributor to, a public good. However it is still important to differentiate an SE from a business focused only on profit-making. SEs are essentially engaged in applying business principles to tackle issues of inequality and poverty. An excellent differentiation of these is illustrated in the quote below by [Townsend, 2006]:

"*It is not enough to describe poverty as a condition applying to those whose disposable income is low relative to that of others. This is to fail to distinguish conceptually between inequality and poverty. Poor people are not just the victims of a maldistribution of resources but, more exactly, they lack, or are denied, the resources to fulfil social demands and observe the customs as well as the unfolding laws, of society. This lends itself to scientific observation, measurement and analysis of multiple deprivations.*"

Note that socially responsible, yet traditional, enterprises are not the same as SEs. The former means that it has some of its own structure dedicated to deal with the socio-economical or environmental matters that are affected through the byproducts of their prime profit-making activity. In contrast, a SE such as a MFI has –as its main objective– the provision of services aimed at mitigating socio-economical or socio-environmental problems.

In this sense, it is useful to consider the variety of enterprises, ranging from being fully philanthropic to fully commercial organisational models. The rectangle in Figure 2.2 below indicates the extensive diversity of SEs [SEUK, 2013, Murray et al., 2010]. SEs are then best understood as hybrid organisational models. This is due to their necessary balance between obtaining social and financial gains. Therefore the further left an organisation is in the depicted spectrum, the less likely it *can* invest any profit back in activities that are aimed at producing social gains. On the other hand, the further right an organisation is in the depicted spectrum, the less likely it *will* invest profits in activities that are aimed at producing social gains. Then a SE that aims at simultaneously solving social / environmental problems and receiving a financial return for that at market rates, such as the studied MFI, follows a social purpose enterprise model.

The leftmost organisations, in the depicted spectrum below, function by being mission-driven, interested in the creation of social value and appealing to the goodwill of stakeholders. Their purpose is geared towards delivering benefits to their target public and are not allowed to pursue profit as an ultimate goal. Its beneficiaries pay nothing, as capital is acquired by donations/grants, and its workforce consists mainly of volunteers.

The rightmost organisations, i.e. fully oriented by commercial gains, contrast in every sense with other organisational models that focus on some hybrid model that includes a social return. That is due to their appeal to self-interest and market-driven creation of economic value, so that its beneficiaries and workforce are paid at market rates.

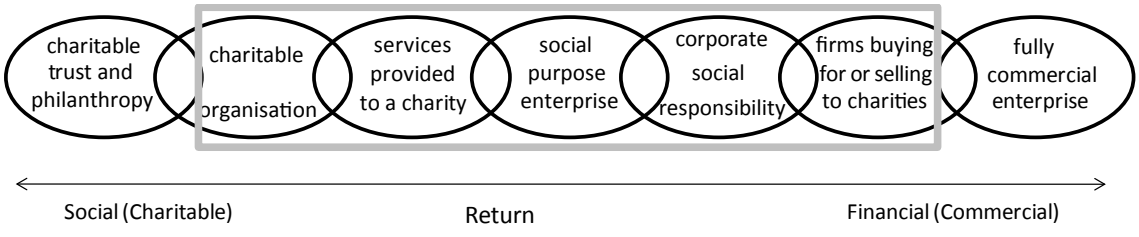


Figure 2.2: Enterprise spectrum, adapted from [Westall, 2009, Allinson et al., 2011]

The need to ensure that SEs are sustainable and not at risk of mission drift has lead to the development of social performance, or social accounting, toolkits [Campion et al., 2008, Zeller et al., 2003] and other measurements of institutional viability depending on the type of SE that one wishes to develop [UNITAR, 2013, Ledgerwood et al., 2013]. MFIs tend to be interested in social accounting/performance as a way to measure poverty/inequality outreach and impact of their policies in multiple levels. These are aimed at assessing how and to which extent SEs actually achieve their proposed social goals. Measuring such impact is often troublesome, as criteria can include evaluation of semi-subjective aspects of well-being and living standards. Reporting on the social impact that SEs and other traditional businesses have often done through self-assessment along with third party audits. These may include silent and shadow reports, which are proposals for a social account based on data that is publicly available and generated by other sources than the organisation in question. This differs from a self-assessment report, which collates data made publicly available by the organisation [Dey, 2007].

The advantages of having different types of assessments include, for instance, helping managers to better understand the circumstances their SEs operate and facilitate donors' decisions as to where their investments should be directed. As a side note, these assessments were underway at the institution surveyed for this research. Yet generally little is known about how the policies of a MFI affect in practice how internal group events (i.e. at the micro-level) are actually dealt with collectively. During this project, prior to the administered data collection, despite institutional interest there was no systematic way of considering the influences from the top-down regulations and from the bottom-up conventional social behaviour within groups. Thus results, particularly those in Section 5.1: "Fieldwork Findings: Credit Officers" (page 101), Section 5.2: "Fieldwork Findings: Microfinance Clients" (page 114), and Section 5.4.1: "Discussion of the EDSM Results" (page 147), contributed to inform the MFI in terms of policy-making and also encouraged the board to systematically collect individual data about the behaviour of participants within their funded groups.

As every SE strives to deliver a social mission, it is important to evaluate how MFIs perform both economically and socially. Figure 2.3 below illustrates a study carried by the Geneva International Academic Network[2], between 2004 and 2006, which analysed the efficiency of 40 MFIs operating in 24 countries all over the world. Their criteria was that each institution should be serving a minimum of 3,000 clients over a minimum of five years, with complete transactional financial records from 1999 to 2003. Despite the varied contexts of where the MFIs operate, the plot depicts that MFIs have generally:

- been inefficient both in social and financial performance (bottom left);
- compromised performance either socially or financially (top left, bottom right);
- and, ideally, been efficient both in social and financial terms (top right);

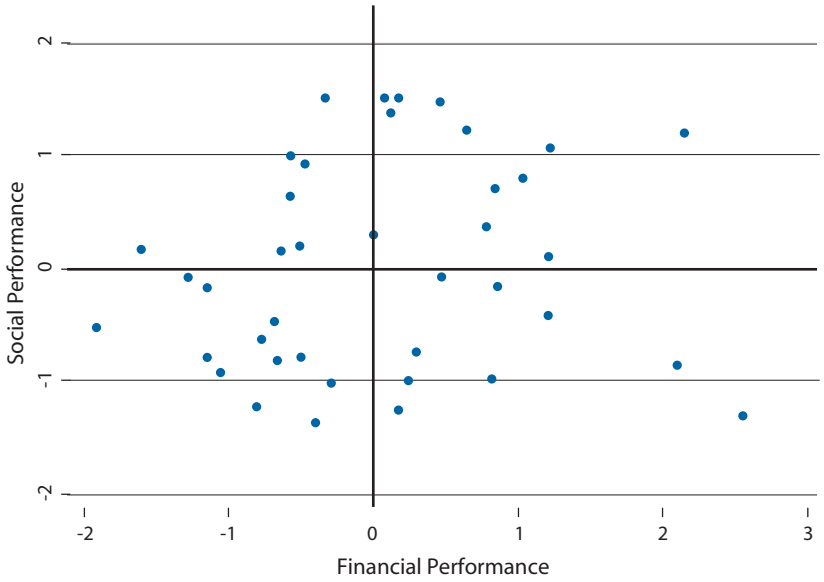


Figure 2.3: 40 MFI social and financial performances, adapted from [MIX, 2007][a]

[a] Cluster and factor analyses based on financial and social performance variables.

This illustrates the discussion on the potential role of the public sector in progressively, and sustainably, integrate MFIs into traditional, non-subsidised markets. That is because an effective MFI operating as a SE can contribute to poverty mitigation, particularly as financial performance is not the only proxy for their efficiency.

[2] This refers to a research project jointly funded by the International Labour Organization, the Geneva Institute of Development Studies, the European Union and the Ford Foundation.

There are, for example, MFIs which are socially efficient in their operations but struggle financially. However the opposite of that, i.e. financially efficient and somewhat socially ineffective, seems more common. There is thus an important role of public policy to assist SEs, such as MFIs, to contribute with poverty mitigation policies. This topic is further discussed in Section 2.3: "Group Lending Approaches in Microfinance" (page 31). To a large extent MFIs used to offer only microcredit products, assuming that clients would essentially graduate out of the program and join other, more traditional, banking institutions. Historically donors have been the primary source of funding, yet that causes a variety of managerial difficulties as funding is unpredictable. These issues affect MFIs by creating difficulties to timely deliver services and also, sometimes, can politically interfere in targeting which clients should benefit from their policies.

Over decades MFIs evolved so that a greater variety of financial products is offered and hence focus changed onto keeping the best customers in the system, along with managing a recruitment program for new customers. The diversification of funding sources became widespread, so that even small institutions may aim at accessing local and international markets. In this sense the most common elements to analyse the viability of MFIs include the: organisation's mission, vision, its board members qualifications, duty to care[3], plus the relationship between management and executives [Klarsfeld et al., 2012]. Figure 2.3, on the previous page, illustrate the fact that MFIs are typically analysed in terms of financial and institutional viability. The latter is of greater interest to this research, as it aims at understanding how enterprises can adapt to fulfil their social missions. Whilst still recognising that donors remain a significant source of funding, generally MFIs tend to operate at basic levels and often strive for "deep outreach" [4] and also financial sustainability. So to better understand the different operational levels a MFI can experience as a provider of SE, one should bear in mind their: market understanding (formal and informal sectors), degree of streamlined operations, repayment administration, anti-delinquency measures, sustainability of interest rates, saving and insurance services. With these under control, a MFI can focus on its social mission.

[3] I.e. the MFI members' adherence to the organisation and personnel well-being.
[4] I.e. the institution does physically reach where clients are, rather than the opposite.

As micro-financial resources are fungible[5], MFIs face a constant pressure to manage multiple financial activities: tracking of loans and savings, liquid assets, access to institutional credit and emergency funds [UNITAR, 2013]. In light of the aforementioned reference regarding an organisation's institutional and financial viability, MFIs have been classified as progressing within and between three levels. Each of them exhibit the following set of features accordingly [UNITAR, 2013, Ledgerwood et al., 2013]:

- Level 1: the institution is not self-sufficient operationally, therefore revenues often fall short of operating expenses. This is due to the organisation still relying almost exclusively on donations for the continuation of operations and erosion of their assets either via inflation side-effects and poor client performance (delinquency or defaulting). The high operational costs of such MFI, combined with the reluctance to charge more sustainable interest rates according to their reality, create a very difficult environment in which to succeed with a SE mission. The MFI effectively act as a freelance intermediary between donors and clients.

- Level 2: the institution is operationally self-sufficient but financially unsustainable due to inflation continuously eroding equity, despite interest rates and fee income that cover operational expenses. The MFI has adopted best practice guidelines, is generally efficient, has satisfactory ratios of client-to-staff, allowing staff to control both client delinquency and defaulting. Funding depends on a combination of donations, savings and bank loans. For this reason MFIs at this level vary from those still relying mostly on donations to those either verging –or experiencing– unsubsidised profitability. This is considered a transitional level.

- Level 3: the institution is both operationally and financially self-sufficient. The former aspect is fully covered from retained earnings, client savings and possibly –but not necessarily– commercial loans. Interest rates and fees cover the cost of services delivery, return on savings and management. The MFI seeks to increase the total equity via profits and attracts investments from other organisations.

[5] I.e. resources that can be interchangeably used by different clients.

The MFI sector at large has been evolving to accommodate different types of institutions, according to the client needs and the regulation of their financial services. These include organisations in different levels of informal and formal development, as discussed on the previous page, which are further illustrated with the examples below. The researched MFI for this project was at level 3, therefore with enough leeway to explore how to improve the delivery of their social mission. This has been done by identifying and exploring how their groups of clients self-organise to repay quotas.

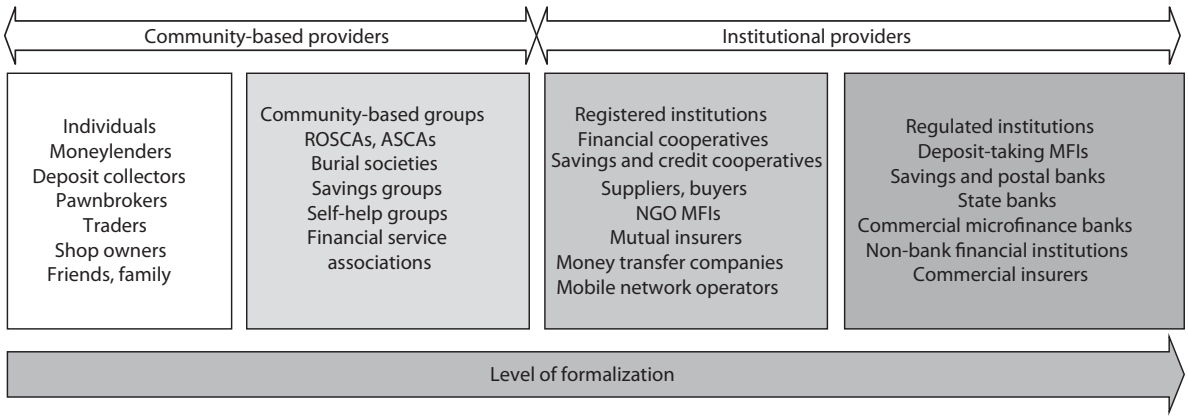


Figure 2.4: Types of micro financiers, adapted from [Ledgerwood et al., 2013]

Although the majority of MFI are established NGOs, the sector has been changing continuously and currently contains a wealth of different service providers worldwide. These range from specialised individual-based initiatives to fully-regulated national commercial banks [Battle, 2009]. The spectrum of the figure above highlights the diversity achieved in 30 years of microfinance: sustainability is achieved with different types of organisations –regardless of whether there are, or not, formal regulations.

Community-based providers tend to be informal and without legal status. These are not considered institutions, thus often are not legally licensed as financial providers. On the other hand, institutional providers tend to be formal and regulated. Even if such organisations are member-owned, a public registration is required and supervision is usually done by a larger public or private sector framework –depending on the MFI.

Each type of organisation presents particular advantages and disadvantages regarding the context of operations, so there is not a single optimal MFI solution. Organisations with greater levels of formalisation, tend to exhibit better levels of institutional and financial viability. These also tend to offer a wider variety of microfinance products and/or a broader spectrum of terms and conditions to suit a greater diversity of clients. For this reason, such institutions may be more reliable in the long-term than community-based providers. Microfinance providers driven by newer technologies, such as based on mobile networks, introduce convenience and enable faster scaling of transactions.

Whilst there has been a continuous increase of commercial MFIs, informal providers[6] remain the main source of microfinance services for the very poor [Ledgerwood et al., 2013]. It is also known that often microfinance clients use more than one provider, be it formal or informal. The level of formality depends on whether there are normative regulations[7] for the type of organisation in question. These in turn, particularly in the domain of microfinance, are influenced by the informal conventions of the society and business community the providers are situated in. A subset of these are the social conventions adopted by the microfinance clients, which has been tapped into this research[8]. As discussed by Ledgerwood et al., in the 2013 "Microfinance Handbook" and others [Coleman, 1998, Shipton, 2007, microLINKS and USAID, 2010], these informal conventions define the acceptable behaviours for individuals based on a combination of factors including culture, value systems, history and practices of the community.

As these conventions do not operate based on the responsibility of just one person, the creation and adoption of acceptable behaviour is necessarily a collective and –most likely– a localised activity within and perhaps also between groups. This research is focused on tapping into the identification of what are these conventions are and on their role amongst the surveyed microfinance clients and an *in situ* ethnographic observation of microcredit groups over one month.

[6] I.e. organisations that are not fully regulated and formalised, as previously discussed.
[7] I.e. written law, government policies and/or industry standards that are enforced.
[8] Chapters 4: "Research Design and Development", 5: "Research Findings" (pages 75, 100).

This project therefore does not focus on the creation and adoption of informal conventions, but rather on better understanding what these are and how these operate with regards to groups that are bound by formal credit rules. The origins of informal conventions are varied and can persist for generations, depending on the circumstances in which these have been created and maintained [microLINKS and USAID, 2010]. These may include historical experiences of ethnic conflict, natural disasters, chronic lack of resources, infrastructure or opportunities. One could argue that communities marked, for example, by significant conflict may be less receptive to group lending frameworks. One can support the effectiveness of microfinance core services, which is the interaction between clients (demand) and service providers (supply), by understanding the local context and informal conventions therein. This can be helpful in terms of organisations:

- developing better capacity, via specialised training or other means of learning[9], both within the service provider and interaction with external policy makers;

- developing, in a coordinated manner, the scaling of microfinance services by planning the actual offset of limitations and capacity of different providers;

- developing human capital resources to provide an appropriate participation of microfinance providers and customers in the wider financial market system[10];

- developing research to provide microfinance organisations with new knowledge and relevant up-to-date evidence that can facilitate the management of services.

Each of the aforementioned aspects above, of course, depends on funding. Organisations with greater levels of formality tend to rely either on private or public investors. In the microfinance industry, however, traditionally there has been a wider range of investors.

[9] Depending on the local industry, with partnerships between the public and private sector.
[10] This activity is also sometimes referred to, in the literature and industry, as advocacy.

As donors and governments do not seek profit, these two are the key enablers of MFIs to deliver their mission as SEs, which are aimed at mitigating issues of under-provision or access to public goods. These have been, and are likely to remain, important providers of resources that enable the infrastructure of SE providers [UNITAR, 2013].

2.2 The Role of Microfinance in Public Goods

The satisfactory provision of public goods, particularly through successful innovative governmental means, can play a significant role in the overall societal welfare and it can provide effective means to mitigate degrees of poverty [Squire, 1993, Timothy and Maitreesh, 2006, World Bank, 1990]. Some examples of welfare-enhancing public goods include health services (e.g., [Timothy and Maitreesh, 2006]), schools (e.g., [Labaree, 1997, Alesina et al., 1999, Timothy and Maitreesh, 2006]), underlying infrastructure for clean water (e.g., [Timothy and Maitreesh, 2006, Shafik, 1994]), provision of urban sanitation (e.g., [Shafik, 1994, Alesina et al., 1999]) and transportation infrastructure such as public roads (e.g., [Alesina et al., 1999, Timothy and Maitreesh, 2006]).

Throughout this thesis microfinance is discussed as a way of improving the livelihood of the poor through facilitating access to public goods, even if that means partly privatising them. Making the poor effectively pay for the provision of public goods without microfinance is a difficult balance. That is because such proposal also implies negating, to some degree, access to public goods to the unsuccessful ones [Mader, 2011a,b]. Thus when state intervention is insufficient to provide adequate access to public goods, microfinance can still promote development by increasing bottom-up market activity. As discussed further in Section 2.4: "Usage of Poverty Lines in Social Enterprise" (page 41), the MFIs operating as a SE do not necessarily seek to fully replace governments for the provision of public goods, but MFIs certainly aim to mitigate issues of access to public goods and provision of more economic opportunities to those living in poverty.

Yet economic theory suggests a general under-provision of public goods [Hardin, 1968]. This is due to the overarching assumption that individuals would behave as the *homo economicus*. That implies in individual behaviour that only selfishly considers one's own costs and benefits, even when these are mainly accrued from others [Cornes and Sandler, 1996]. In other words, following the classic economic theory, one would take into account the assumed tendency for individuals to be self-interested. Thus, unless there are institutions enforcing behaviour towards promoting the public good, these will tend to not collaborate to achieve what are essentially collective interests [Olson, 1971].

Despite the central hypothesis in the economic argument that individuals are essentially selfish, there are also insights from behavioural and experimental economics suggesting that individuals can also concede substantial amounts of their own benefit to improve the circumstances of others [Gächter, 2010]. This in turn implies that there is heterogeneity in the underlying individual social preferences towards public goods, and this has been documented experimentally [De Oliveira et al., 2009, Fischbacher and Gachter, 2010]. Therefore one can explore this relationship between group heterogeneity and the provision of public goods, in terms of a potentially negative relationship [Alesina et al., 1999, Miguel and Gugerty, 2005, Vigdor, 2004] with regards to the group composition of a public good [Fischbacher and Gachter, 2010, Gächter and Thöni, 2005].

In this regard, it is known that the poor can strive considerably to help others in their social circle if necessary [Collins et al., 2009]. Those living in poverty can be influenced by a variety of factors, which may simultaneously influence on when one should group together to improve their individual situation and their community welfare. In this sense public goods that are voluntarily provided can be of great importance to low-income communities. This role is particularly important when aid from the state is misapplied (e.g. due to to corruption) or is insufficient (e.g. lacking resources, for whichever reason).

One of the best established links between diversity and welfare is the relationship to growth; albeit it is debatable as to whether this mechanism is causal [Ahn et al., 2003, Easterly and Levine, 1997, Costa and Kahn, 2003]. A higher income can improve welfare, but welfare is also affected through other mechanisms such as quality of governance [Mauro, 1995]. These variations are bound by the concept of fractionalisation, which is also referred to in the literature as systemic heterogeneity or diversity, and has an overall negative impact on public goods. These include governmental services [Alesina et al., 1999, Banerjee and Somanathan, 2007], voluntary work [Miguel and Gugerty, 2005, Vigdor, 2004], and community participation [Alesina and Ferrara, 2000].

Nevertheless appropriate policies can be implemented to overcome difficulties imposed by high levels of fractionalisation in public goods [Banerjee and Somanathan, 2007, Miguel, 2004]. Hence, at least theoretically, diversity can also be positively related to growth by inspiring new ideas and innovation within communities. Yet that is only the case when the difficulties to manage diverse interests remain somehow under control. Otherwise the positive effects of diversity may be forced to deal with the structurally overwhelming difficulties of providing a public good to a very diversified set of clients.

The best known way to prevent such undesirable scenario is the design and maintenance of effective institutions [Easterly, 2000]. Research pointing to the negative effects of diversity in the provision of public goods generally rely on demographics to examine heterogeneity; with an argument that this characteristic reduces the ability to promote positive social preferences (e.g. trust and cooperation) [Ahn et al., 2003, Easterly and Levine, 1997, Mauro, 1995, Alesina et al., 1999, Miguel and Gugerty, 2005, Vigdor, 2004]. This is partially due to the researchers' inability to reliably either measure or experimentally affect individual social preferences on a large scale. Hence the lack of behavioural data, both empirical and experimental, has generally hampered attempts to deductively investigate and demonstrate what is the relationship between heterogeneity in individual preferences and voluntary contributions to public goods.

2.3 Group Lending Approaches in Microfinance

There are different frameworks that implement microfinance as a SE, yet all of them are based on the idea of shared responsibility to repay quotas via a group lending approach. For four decades the original microcredit framework has been evolving various aspects to better suit services according to a variety of local demands. Both solidarity (collective) and individual lending can be available as SEs through {micro}credit services. This thesis is focused on discussing the former case, as it requires social collateral to function, which is the backup of collective responsibility over credit using one's own social network. There is to date a strong tendency in the microfinance industry to primarily serve women. This is due to consistent worldwide evidence supporting that women tend to invest more earnings to improve living conditions of their household and default less often than men [MIX, 2009, 2010, ILO, 2002, Armendariz and Morduch, 2005]. According to these, the studied MFI in this thesis[11] can be considered to be:

- mature and not-for-profit nature (i.e. it has been operating for at least 8 years);
- with medium outreach (i.e., serving between 10.000 and 30.000 clients);
- having a low financial intermediation (i.e. their total voluntary savings divided by total assets is equal to less than 20% of the total financial portfolio);
- and is focused on the low end market (i.e. the average balance per borrower is less than the local equivalent of 150 United States Dollars – henceforth USD).

The studied MFI has also participated without loss, during 2009, in the Kiva.org[12] peer-to-peer funding scheme. As microcredit schemes lend to their clients without any traditional collateral, apart from their social collateral, repayment cycles tend to be much and require smaller credit quota amounts that clients have to repay than the commercial loans that are typically available at mainstream banks.

[11] A more in-depth discussion is in Chapter 5: "Research Findings" (page 100).
[12] Based in the United States, it allows individuals to invest via the Internet in local social entrepreneurs around the world, whose loans are mediated on the ground by a partner MFI.

This difference is important as microcredit frameworks are systems where quota instalments are generally designed to encourage a rapid increase in the amount that individual clients are dealing within their financed groups. At times the interest rate of microcredits can be substantially higher than traditional bank loans, as institutions rely on such earnings to cover the relative high administrative costs associated with numerous small loans. This is a difficult challenge, especially for young and small institutions, as external funding is usually necessary to keep operations smooth. Many MFIs also offer different SE services to their clients, such as basic healthcare and education, either via themselves or in partnership with other organisations. Many modern SEs tend to tailor services both to cover foreseeable events and unforeseeable adversities[13] as fully-fledged, yet still financially independent, extras to the microfinance services. Since microcredit clients rely both on the individual capabilities and their social network capacity to succeed, group size and group portfolio are important aspects to consider for these institutions. A MFI has to devise a minimum group size that is small enough to encourage joint responsibility and prevent free riders, yet with a maximum that allows prevention of its own collapse in case members experience adversities. The researched MFI for this project deals with groups ranging from three to seven members. For more details on this, please see Section 4.1: "The MFI Context during Data Collection" (page 77).

Figure 2.5 on the next page depicts, at a high level of abstraction, the observed cycles and states requiring liaison between credit officers and clients in the MFI operations. Basically, if clients already know the terms of the microfinance services, they may form groups and apply for credit collectively. If all participants meet the MFI socio-economic criteria, credit is granted to all applicants who now are jointly responsible to repay that amount in due time. If the application is unsuccessful, the whole procedure is then terminated. Once credit has been distributed to all group members, credit officers regularly update the MFI records with regards to the payment activity of every financed individual in a group.

[13] Examples include: bad investments, unprofitability and illnesses. For this thesis, some of those adversities have been modelled as shocks to the simulated microfinance groups. Please see Table 5.23: "Configurable parameters for group circumstances in the EDSM", Chapter 3: "Agent-Based Social Simulation" (page 137) for more details on about the proposed approach.

As discussed in Section 5.1: "Fieldwork Findings: Credit Officers" (page 101) and Section 5.2: "Fieldwork Findings: Microfinance Clients" (page 114), mutual social and financial monitoring amongst members is crucial for reducing moral hazard[14] in groups.

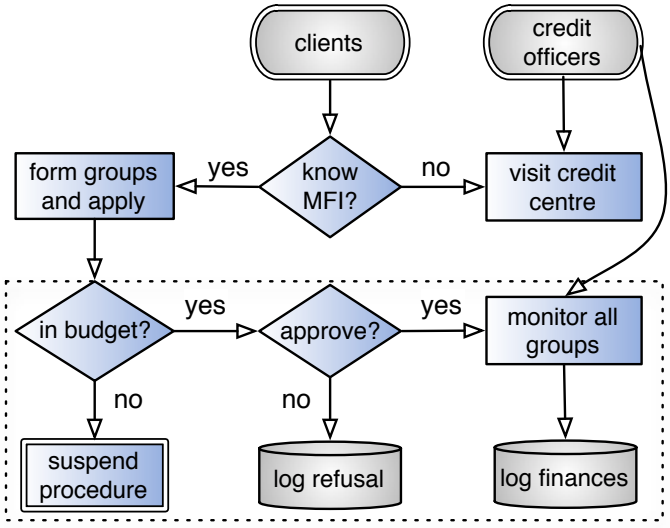


Figure 2.5: Cycles involving officers and clients, based on observing the MFI

The dotted line represents the financial management tasks that are, usually in the case of branchless[15] microfinance and banking, only partially done at the MFI headquarters [Mas, 2009, Helms, 2006, CGAP and FGV, 2010]. The operations of the studied MFI are effectively branchless as the institution employs a mobile network of retail credit agents. Regardless whether the bulk of operations are carried in centralised or distributed credit offices, only the credit officers systematically collect client data. To date the only known exception known to the author is when microcredit quotas are paid via mobile phones. This is still rather uncommon as affordable mobile banking is generally unavailable to the very poor communities throughout the world. Even when clients manage larger amounts of money, often institutions do not offer electronic means of repaying quotas. I.e. groups are likely to not have access to devices with reasonable, regular terms of usage like M-Pesa, which is a Kenyan mobile money-transfer system, pioneered in 2005.

[14] I.e. no incentives to protect from risks in which one cannot be affected by its consequences.
[15] That is, all MFI clients are visited by credit officers who are based at a central office.

Despite the fast adoption of mobile technology in some developing countries [Pohjola, 2003], access and maintenance costs for these to be used in MFIs are generally still prohibitive. Unless there are specific subsidies (public and/or private) to launch affordable mobile services, the networks' terms of usage –even when these are less expensive than landlines– tend to be unfit for the purpose of those living below poverty lines. M-Pesa is a good example of a mobile banking system that managed to be affordable[16] and thus has become popular for local money transfers in Kenya [Mas and Morawczynski, 2009]. This service became so successful that in 2008 it partnered with Western Union[17] to pilot a cross-border mobile money transfer service with the UK [Omwansa, 2009].

This is an example of the importance to properly regulate the cooperation between social (e.g. microfinance) and commercial (e.g. mobile) enterprises targeting the poor. As a reference, according to [Lyman, 2009, Morawczynski and Pickens, 2009], since its 2007 commercial launch, M-Pesa had nearly seven million clients and is responsible for daily transfers averaging 1.96 million USD, with a total transfer of 1.7 billion USD; of which 80% are under 50 USD and 50% under 10 USD. This service enabled, for the unbanked, to access banking services simply by owning a mobile phone. This is a significant achievement, as thousands of merchants facilitate individuals to open accounts, handle deposits and withdrawals based on the customers' mobiles. An ethnographic fieldwork was carried out interviewing about 350 M-Pesa clients, 14 financial diaries and 21 focus groups in two communities in Kenya, Kibera and Bukura [Morawczynski, 2009]. The study revealed that most transfers are of either nature: (a) frequent regular income-supplementing (small sums for general use) or (b) occasional lump sums for specific investments (e.g. education and productivity). Most senders are urban men, whilst most recipients are rural women or retirees. Despite its success, problems with the M-Pesa system include: the network overload that results in failed transactions –either in terms of notifying either side or not processing them at all. This happens as the same bandwidth is used for all users of mobile services (i.e. data, voice, text).

[16] Through a 2005 private (Vodafone, the holding company of Kenya's Safaricom mobile network) and governmental (UK Department of International Development) sectors collaboration.
[17] An international branch-based money transfer service that is popular with the unbanked.

Microfinance provided by Rotating Savings and Credit Associations

There are other settings for collective and solidarity-based lending schemes that differ from traditional MFIs as SEs. This includes the informal Rotating Savings and Credit Associations (henceforth ROSCAs) and the Accumulating Savings and Credit Associations (henceforth ASCAs) [Bouman, 1995, Ledgerwood et al., 2013]. In both schemes all group participants are themselves informally responsible, i.e. without any formal institutional organisation, to manage their own individual quotas. The main difference is that the latter case (ASCAS) may require the appointment of one person per group to keep track of deposits and lending surpluses. As in the formal microfinance framework, these two aforementioned schemes are focused on exploiting the social network and social collateral of poor individuals to enhance the likelihood of successful collective financing. ROSCAs and ASCAs contain context-specific social conventions for supporting and sanctioning individuals, similar in kind to those observed and discussed during the development of this doctoral thesis[18]. In this sense it is remarkable to observe that collective financial cooperation can be sustained through social conventions alone, and not necessarily be backed with a formal set of potential penalisations. Across the microfinance frameworks, as in ROSCAs and ASCAs, there is generally a strong presence of social and financial commitment between participants, which arguably helps them to repay quotas in time [Van Bastelaer, 2000, Ito, 2003, Rutherford and Arora, 2011].

The relevance of personal relationships in social networks has a very prominent role in group lending for the poor. This aspect is particularly important in microfinance as it has allowed to scale up variations of the original framework to reach far more clients than other similar schemes. In this regard, the formal shape of an institution can indeed be designed to help this synergy. That is because MFI regulations have a direct impact on how groups are organised over time, as the member's reliability are essentially tied with the socio-economic conventions of what is considered acceptable behaviour in groups. For example, whenever voluntary cooperation fails to materialise, social pressure through ostracising and embarrassment can be deployed as sanctions –and, in certain circumstances, group-level fines may also be managed by groups.

[18] For a more in depth discussion on this topics, please refer to Section 5.2: "Fieldwork Findings: Microfinance Clients" (page 114, Chapter 5: "Research Findings").

This has been observed elsewhere and in the fieldwork carried out for this project [Van Bastelaer, 2000, Lucas, 2009b][19]. These strategies employed by group participants filter out opportunists, which are also referred to in the literature as free riders. In other words, borrowers themselves can assume the responsibility, instead of the financing institution, to select and manage the clients participating in their collective credit. The major MFI schemes in operation tend to differ from ROSCAs and ASCAs in terms of how their rules are pragmatically linked to the concept of social collateral. That is primarily noticeable in terms of having collective credit tracked by both the financier institution and participants, which may involve legal join liability towards clients. The Grameen Bank and various adaptations based on their framework, such as the one discussed in this thesis' case study, do not require that [Grameen Bank, 2010, Stiglitz, 1990, Ghatak, 2000, 2002], and only implement an informal notion of it. I.e. in such systems there is no attempt of legally enforcing rules against defaulters. On the other hand, no client would be able to renew credit in case their group debt is left outstanding. In this way, the selection of participants tends to be assortative whenever possible during the screening process. Due to the usual transport limitations[20] in the areas where –typically rural– clients live, this may also be constrained by location[21].

The case study presented in this thesis[22], is an adaptation of the Grameen framework with aspects borrowed from another major microfinance organisation. That is the Foundation for International Community Assistance (henceforth FINCA), founded in 1984 and known for being a synonym with village banking[23]. The latter requires their financial services being similar to the ROSCAs, as participants receive –in a round-robin fashion (i.e. sequentially and periodically)– loans from the mandatory savings gathered from all group members [Karlan, 2007]. The studied MFI in Chiapas, the southernmost Mexican state, also has savings services but those are not allowed to be used for repaying credit. This practice varies within the different setups of MFIs, as

[19] The latter reference is available in Appendix III: Second Fieldwork Report (page 192).
[20] I.e. difficulties in accessing it, such as cost and limited routes or timetables.
[21] This may also impose restrictions as to which type of business one can pursue.
[22] See Section 4.1: "The MFI Context during Data Collection" (page 76.
[23] I.e. microcredit that is administered via local, fixed branches instead of a centralised one.

on the other hand, FINCA employees must continuously emphasise to clients the need for groups to monitor their members. This is because otherwise FINCA itself will be serving as the collateral for the loan. This means that defaulting groups –in theory– pose a greater risk to FINCA than in other microfinance frameworks where savings expenditure are exclusively set for different purposes –as every collateralised risk is confined within groups. Another major difference, between FINCA and the studied MFI framework, is that clients of the former structure must reach their branches by themselves. That can happen through invitations or individual initiative, and clients are not able to choose –neither *a priori* nor *a posteriori*– in their applications which group they shall join. Potential clients are put on a list and, when that reaches a certain number[24], a group is automatically formed. FINCA is thus relying, rather heavily, on the increasing awareness of their operations through informal word-of-mouth recommendations within the community where their branches are based, as no explicit instructions to existing clients or advertising are given in order to find new credit applicants. This framework is centralised and does not take advantage of the emergent properties derived from an individualised peer selection process for group formation, as the entire process is controlled by FINCA as an institution. Weekly meetings, held at their distributed MFI offices, encapsulate and regiment all the activities that monitor every financed group.

The aforementioned descriptions contrast with the MFI studied in this thesis, as the meetings to monitor groups take place simultaneously in distributed centres across a large geographical region. Thus collecting and merging data of their multiple clients is a completely asynchronous undertaking. Reviewing default events, and deciding what to do in each occasion, is different in these two cases. FINCA employees supervise and may interfere in this process by assigning clients who deal with defaulters or late payers. Such decisions in the studied MFI are made differently, as every action is entirely managed by clients, without the full knowledge of the credit officers. A more detailed discussion about this can be read in Section 5.2: “Fieldwork Findings: Microfinance Clients” (page 114).

[24] Groups financed by FINCA may contain, at their discretion, from 10 to 50 members.

This is an important distinction as it affects how top-down (institutional) rules influence bottom-up (group level) social behaviour to deal with defaulters. The FINCA framework, due to greater centralisation, is more restrictive than the Grameen Bank framework. The legal context in which SEs operate is often challenging as more traditional types of businesses –due to historical reasons– usually already have specific regulations that facilitate their operations and long-term planning. It is intricate to design a well-balanced, country-wide policies that allow favourable conditions for SEs to develop. Traditional business models are likely to have a better and more established legal framework, which helps with growth due to experience. SEs often face challenges without having the backup of appropriate regulations and, sometimes as a consequence of that, also lack investments[25]. With specific legislation SEs could be entitled to incen-tives through fiscal systems or other businesses interested in supporting their initiatives. Solutions in this regard are invariably local ones, as the social context warranting the existence of SEs is very varied throughout the world [Defourny and Nyssens, 2010].

In developing economies such as Mexico, this thesis' case study, state-wide regulations about microfinance are often linked –due to local political reasons– with the legislation of economic cooperatives –which may not strictly be a SE. The Mexican segmentation of financial institutions is based on size and legal structure, essentially meaning that both traditional enterprises and SEs can offer microfinance services [Rosenberg, 2007]. That can be beneficial to clients due to more competition and specialisation of financial products, yet in addition MFIs are also legally allowed to explicitly concentrate on profit-making. An example of that is the Compartamos MFI[26], which brought their business to an IPO[27] in April 2007, despite severe criticisms from the industry [Yunus, 2007]. If not properly regulated, microfinance may undermine development as clients can act as the engine of profit-making and still not mitigate their own poverty. To date in Mexico it is not straightforward to identify and analyse the socio-economic impact of an SE as there is no strict differentiation between MFI as SE from commercial ventures.

[25] I.e. apart from sources such as philanthropy or individual donations from society.
[26] Known in the industry for high interest rates, sometimes over 80% [Rosenberg, 2007].
[27] I.e., Initial Public Offering: the first time a firm issues shares for stock market investment.

Monitoring and Enforcing Collective Responsibilities in Microfinance

The need for self-monitoring within groups effectively transfers much of the lender's responsibilities, and of assessing information uncertainties, to borrowers themselves as they must rely on personal relationships to ensure group cooperation [Grameen Bank, 2010]. Social networks are often put in context as an effective social collateral that allows the distinction of genuine personal negative shocks from individual dishonesty or reneging. But disorganised group lending schemes could lead to higher default rates than individual lending ones. For example, individuals paying on time may decide to retaliate against defaulters by either also not paying their quotas, or refusing to cover in-group eventual defaults, as a new loan would not be granted anyway. That would have been considered an anti-social action within the credit group. Such attitude would be likely to hinder an individual's own ability to renew credit, but it also may spur the formation of a new group altogether that may apply for further new credit instalments.

Some MFIs, for example the one studied in this research, do not track individual information as to who did not cover defaults, so such anti-social behaviour would pass unnoticed by the institutional financiers. The same situation is less likely to be unknown amongst the local microfinance clientele themselves, as an anti-social participant can significantly impair his/her own collateralised social network. That is, the individual web of contacts can directly contribute to enhance or worsen reputations over time. Such a hypothetical scenario is plausible and probably has already happened in the studied MFI, but the local social conventions between group members may also have already filtered out such individuals over time. This illustrates the rather powerful means of bottom-up self-organisation regarding joint liability that can, at least in part, be supported with top-down (institutional) rules designed specifically for that purpose. In essence, this would mean that microfinance groups are encouraged to gradually take over the underwriting, monitoring, and enforcement of collective loan contracts. The nature of self-formed groups incentivise individuals to collectively avoid unreliable participants, as otherwise these can adversely affect their own group performance and ability to remain funded by the organisation responsible for the provision of credit.

In this regard, one can observe culturally-dependent variations as to how such group-level conventional social behaviour is shaped. Lending policies are influential for group performance, as such top-down regulations may support or hinder aspects that contribute to the success of a group lending framework [Woolcock, 1999]. There are differences all over the world regarding to what is considered to be the best approach to manage non-financial aspects of a microfinance framework [Guttman, 2007]. Nevertheless group lending, based on social collateral, has been substantially successful by coupling the advantages of endogenous peer selection with the intention to achieve high repayment rates [Brau and Woller, 2004, Ghatak, 1999]. Yet there are also microcredit loans specifically designed for other purposes than productive, enterprise-focused investments. These loans, despite providing important improvements in the livelihood of those who are living in poverty, are not the focus of the discussion in this research thesis. Instead, the discussion is focused on micro loans used for economically profitable activities.

Individual reputation is a key aspect for social collateral to work effectively, as one's exposure to inappropriate actions could adversely impact one's ability to access further credit and perhaps also to do business with others in the local community. The experience obtained during this research project generally corroborates to this fact:

"... group borrowers must in effect meet collateral requirements not just as borrowers but also as monitors. [...] group loans will only be chosen over other sources of finance when group members have a decided cost advantage in monitoring and sanctioning each other relative to outside lenders and intermediaries." [Conning, 1996]

The difficulty is then to assess the quality and value of social collateral. Unless there is previous knowledge about the applicants' networks, there is no effective way to appraise social collateral before actually granting credit to groups. This uncertainty regarding creditworthiness, along with the similar socio-economic circumstances of first-time borrowers, justify –at least in part– the usual low credit and high interest rates offered –often genuinely in *bona fide*– to inexperienced clients [Hermes et al., 2005].

2.4 Usage of Poverty Lines in Social Enterprise

After understanding the different ways to control group lending, through managing the concept of social collateral, another instrumental concept to grasp is the role of poverty lines in SEs. These are helpful in assessing clients on whether these should receive collective funding. Thus instead of traditional assets serving as collateral for credit, a social network is used to backup credit by assigning it a collective repayment responsibility. Peer pressure may thus be understood as a component of social capital, which in this case is exercised by group participants towards achieving a common goal [Ito, 2003]. In the microfinance framework this is ensured by the top-down institutional rules on how credit should be repaid. If someone in a group defaults, nobody in that group would be allowed to access further credit. In this way, social collateral works as a guarantee for renewing credit as that depends on cooperative repayment behaviour from all group members. The ASCA and ROSCA saving and funding frameworks (discussed in the previous section on page 35), employ social collateral but have no external regulation[28] to implement joint liability over shared assets. This means that groups are required to self-organise in terms of strategies to meet their individual obligations as part of a collective obligation. That is the foundation of microfinance services.

Individuals living close to a poverty line, i.e. those adversely affected to reach the minimum estimated income needed to secure life necessities, have been historically denied formal credit due to lenders' difficulties, both in terms of logistics and cost, to assess such potential clients. That include limited and expensive means of screening new applicants, monitoring credit and enforcing repayment of the would-be clients. The formal monitoring of individual performance is important for MFIs to determine which and how their clients should be sanctioned or encouraged. These tasks in traditional credit management schemes needed fundamental changes for the creation of collective finance frameworks that rely mainly on social collateral, as then peer monitoring and enforcement –inline with the institutional rules– can be done by clients themselves.

[28] I.e. enforcement requires no legal apparatus –apart from some variations such as FINCA.

As introduced in the previous section, poverty lines are essentially local socio-economic definitions that are used to identify how adversely affected individuals are in terms of fulfilling the basic and immediate living necessities in a particular geographical area. Since the 1960s various national and international measures have been adopted to evaluate –either in relative terms to local citizens or absolute thresholds[29]– different standards of living. Approaches range from measures of social security and welfare benefits, relative income of an equivalised national average[30], a minimum basket of goods of living needs and an absolute threshold separating those living in poverty. Comparing and assessing poverty trends has been difficult as quality of datasets and definitions vary considerably across individual –or group of– countries around the world [Srinivasan, 2004]. This lead the World Bank (henceforth WB) to propose a common international poverty threshold, which was set in the 1990s as one USD per day[31] and it is regularly updated[32] using the trade-based Purchase Power Parity (henceforth PPP)[33].

Whilst these measures (poverty lines and PPP) have been intuitively useful for benchmarking purposes, such as tracking the 2015 milestones of the Millennium Development Goals (henceforth MDG) [United Nations, 2010], this is still a non-consensual approach. As a result, the PPP is best understood as providing an approximative yardstick to the multi-faceted challenge of poverty. It uses a universal definition of what constitutes poverty and deprivation [Sinha, 2006]. As a consequence one should expect some variation when interpreting reported relative or absolute poverty rates. For instance, 2008 figures for the Mexican population –according to [CIA, 2008] – are 18.2% in terms of food-based poverty, 47% in terms of asset-based poverty[34] and –according to [World Bank, 2005]– these values up to 2004 are respectively reported as 17.6% and 47.7%.

[29] The former is used in developed economies, whilst the latter is used in developing ones.
[30] I.e. an average based on household members weighting differently according to occupations.
[31] Roughly corresponding to the poverty lines of some of the poorest countries in about 1985.
[32] In 2005 the UN updated the MDG poverty line to 1.25 USD [Ravallion et al., 2009].
[33] I.e. a price comparison between two countries, assuming negligible transaction costs.
[34] I.e. considering household expenditures in housing, clothing and transport.

The latter reference has the additional capacities-based poverty[35] at 24.5%. A significative lowering of overall poverty has been observed amongst the Mexican rural population, where indicators improved, between 2000-2004, from 42.4% to 27.9%. That means extreme poverty[36] has been considerably reduced in the country. Amongst the rural population (60.7% of the surveyed people), 35.1% were agricultural workers, 43% self-employed and 71.8% with incomplete primary schooling. Nevertheless, when local data is aggregated over time or space and benchmarked with an index such as the PPP, the usefulness of universal poverty indicators for forecasting purposes becomes questionable. This happens as changes by locally relevant socio-economic events can be statistically unobservable at the aggregate level and structural breaks (i.e. non-stationary trends) could be present in time series [Srinivasan, 2004, Chatfield, 2000].

The rather arbitrary exercise of calculating a global poverty line, which is then deployed alongside the PPP, does not necessarily reflect the actual cost of meeting one's essential consumption and services requirements. There are various examples, in numerous developing and developed economies, where a single raw (i.e. unprocessed) food item can cost considerably more than one or two USD per day. This illustrates how the aforementioned approach is potentially problematic in terms of using PPP-based approximations to consumption needs. That is due to the requirement of aggregation of prices[37] from different countries, which can have substantially different socio-economic circumstances. Therefore, there is no worldwide standard, or a detailed set of income-dependent capabilities to evaluate someone as non-poor; nor a systematic way to assess which resources –in each country– would be required to appropriately evaluate poverty. One potentially useful approach could be the definition of minimum local costs one has to achieve the recommended daily calorie intake, whilst taking into account other local non-nutritional costs in this process. That would be a similar approach to the current UN and WB approaches, but without using a global, currency-based approximation to costs that is subject to constant trade-influenceable aggregations.

[35] I.e. non- food available income for spending on education and health services.
[36] I.e. the share of the population considered as being under the food poverty line.
[37] Frequently such nation-wide data is either unavailable, considerably outdated or estimated.

Nevertheless the current PPP approach is still the most widely used threshold and has been improved over the years with more reliable prices provided regularly by the WB initiative entitled "International Comparison Program"[38]. Figure 2.6 below depicts the threats facing those considered to be either slightly above or under poverty lines. Effective precautionary and mitigation tools –including e.g. microfinance services including credit and savings targeted at the extremely poor. Other tools would be socio-economic safety nets[39] to the moderately poor– are necessary for a smoother individual absorption[40] of both exogenous and endogenous socio-economic shocks. Once in severe crisis (extreme poverty), it is indeed a tough struggle to gradually improve one's own socio-economic condition by means of safely increasing income and accumulating assets.

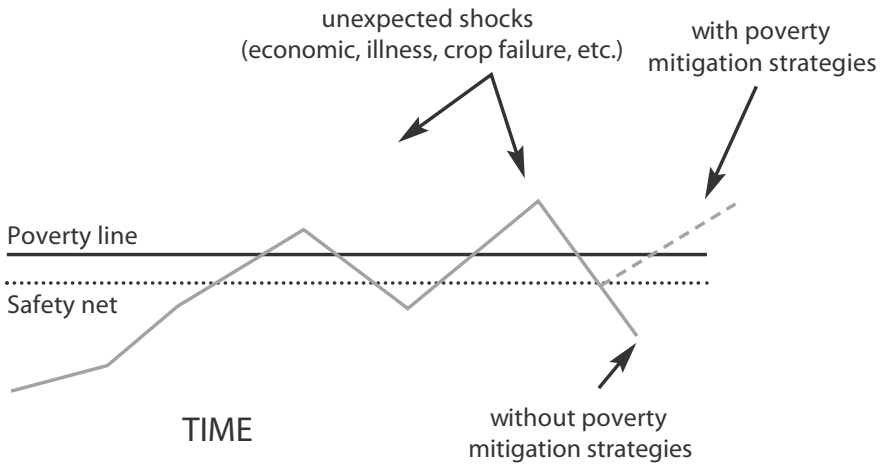


Figure 2.6: Threats close to a poverty line, adapted from [Churchill, 2007]

Both commercial and subsidised tools can provide some of the necessary means for reducing the impact of economic downturns. The application of economic development policies should reduce the vulnerability of those facing various adversities imposed due to economic deprivation and lack of access to basic services, such as sufficient sanitation and education. Therefore if one's economic pressures exceed the household expenditure capacity, there should be public-sector alternatives that allow an appropriate socio-economic protection to fill in such gaps –until the circumstances are overcome.

[38] A global statistical partnership to collect, compile and estimate PPP-based price datasets.
[39] I.e. resource-transfer programs, lead either by the public (e.g. governments) or private sector (e.g. SEs), that are designed to prevent further worsening of vulnerable communities.
[40] I.e. without significantly eroding the limited –if at all existent– regular income or savings.

Figure 2.7 depicts examples of initiatives that have been used throughout the world to tackle this issue, with the aid of poverty lines. Such a yardstick helps to identify and delineate the needs of those in extreme poverty, which is the fulfilment of basic needs (e.g. health, shelter and training). Right above the poverty line there is the economically-active poor[41] which may access microfinance services (e.g. credit and savings). The aim of microfinance is to progress these to the lower-middle income class[42] and so access standard commercial financial services. The categories presented below and on the previous page are broad and require no strict definition in terms of numerical income, as the absolute values will vary across local and world regions.

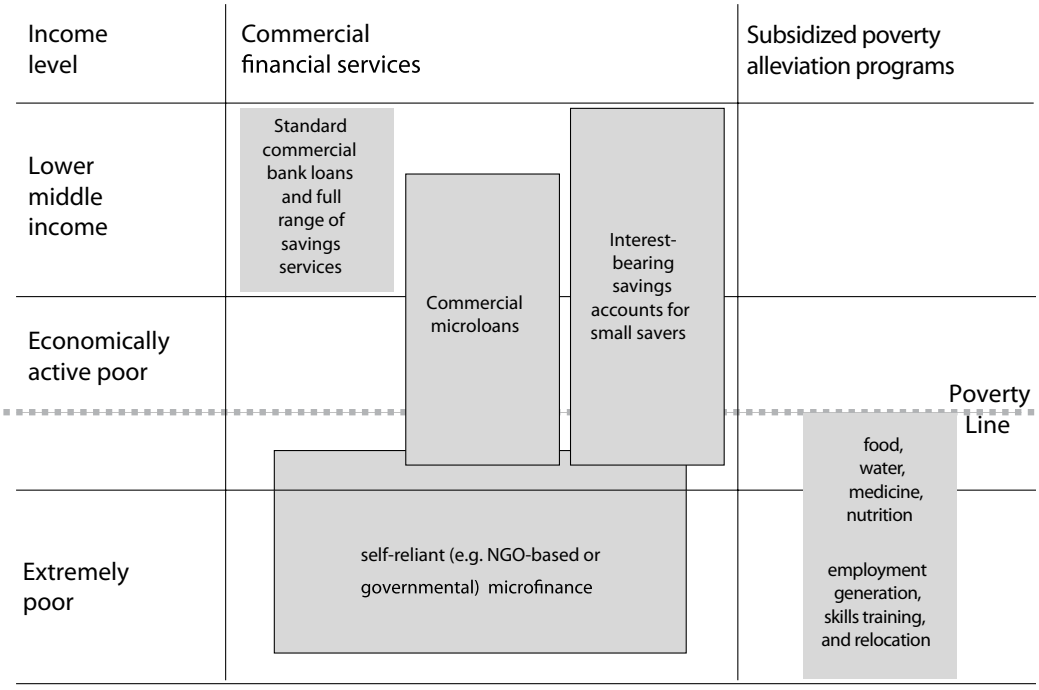


Figure 2.7: Tools for poverty alleviation, adapted from [Robinson, 2001]

Chronic insecurity affect those close to a poverty line with a constant risk of severe income shocks. As a reference, in 2005 the world population consisted of: 25.7% (1.4 billion) poor people relative to a 1.25 USD per day poverty line, 32.1% (1.751 billion) were at risk by having an income between 1.25 USD and 2.50 USD per day and 60% (3140.2 million) if the poverty line income yardstick was set to 2.50 USD [Islam, 2009].

[41] Which may, to some extent, overlap with the moderate poor depicted in Figure 2.6.
[42] Which is roughly equivalent to the vulnerable non-poor category depicted in Figure 2.6.

In 2004, the Microcredit Summit Campaign reported that there were 3,044 MFIs in developing countries giving microloans to over 92 million clients [United Nations, 2006]. There is some discussion as to whether microfinance can be efficiently employed to help the extremely poor [Biggar, 2009]. This is suggested in the bottom middle section of Figure 2.7, due to their more urgent and basic life needs. Assessing microfinance efficacy in mitigating poverty outreach is not a straightforward task. That is why working a poverty line can help understand aspects of financial sustainability, social performance and also devise methods to assess at what stage of poverty someone actually is. Amongst numerous poverty assessment tools that work with poverty lines, probably the two most prominent ones used in the current microfinance industry are the:

- Grameen Bank initiative entitled Progress out of Poverty Index (henceforth PPI), which is a country-specific scorecard[43] set to systematically track poverty levels over time [Schreiner et al., 2002, Schreiner, 2009]. This approach tackles many problems of using generic poverty lines, which is discussed on page 43 in this section, as it uses a national poverty line adjusted to country characteristics, taking into account the one or two USD per day PPP international poverty lines.

- United States Agency for International Development[44] (henceforth USAID) initiative entitled Poverty Assessment Tool[45], which uses a single PPP-based international poverty line to define poverty degrees and, via legally binding regulations, allocates a certain amount of funding towards each category [USAID, 2008].

The PPI criteria includes aspects as access to sanitation, schooling (literacy and numeracy skills), use of telecommunication technology, flooring, cooking utensils, fuel consumption, entertainment and housing structure. Depending on the PPI score obtained, MFIs can classify each household according to a table that proportionally segments a national poverty line, allowing specific reports per household. The studied MFI works with the PPI to evaluate achievements of their social mission of serving the poorest.

[43] Which is about assessing and monitoring organisational change and not only statistics.
[44] A government-led agency charged with administering non-military aid to foreign civilians.
[45] The IRIS Center, University of Maryland, is commissioned with the PAT development.

Summary and Conclusions of Chapter 2: Social Enterprise

The chapter discussed the structure in which the concept of Social Enterprise, which includes examples such as the MFI studied for this research project, and how other organisations are contextualised in terms of the following relevant operational aspects:

- private and mixed (i.e. institutions operating with public and private capital) means of providing, directly or indirectly, alternatice access to public goods;
- ways of operationalising collective credit frameworks as a Social Enterprise;
- and how social collateral can be used in conjunction with poverty lines to enable Social Enterprises to provide their clients with better access to public goods.

Microfinance can be implemented with different group lending frameworks, yet these all depend on the concept of social collateral and are adapted by an MFI using a poverty line as a baseline yardstick for assessing the collateral of credit groups. Thus a conclusion from this chapter is that, in order to understand and track the the delivery of a SE mission via microfinance, it is not enough to assess the economic performance of a MFI. Yet this is the predominant approach used to research behaviour within these micro-credit groups.

Financial soundness is the first requirement for an institution to sustainably pursue a social mission. Thus, despite the wealth of information regarding the assessment of MFIs operating as SEs, there are a number of open challenges to further understanding and exploring the internal dynamics within credit groups. These include key research questions such as: “What are the credit clients’ typical actions regarding missed meetings and payments?” and “What does the MFI know about clients’ actions regarding missed meetings and payments?”.

Chapter 3

Agent-Based Social Simulation

This chapter contains key discussions to understand the role of scientific models, including simulations, with highlights of the most important differences between th kinds of modelling and a conclusion as to why an agent-based approach has been chosen as the most appropriate simulation approach for this research project. The chapter begins with an introductory discussion on the variety of scientific models, including how different approaches to implementing simulation models are situated within that context. Then the next section contains a discussion on the aspects that are particularly relevant to the development of agent-based simulations. The following subsection contain a discussion on the different approaches to building an ABM then another subsection contains a discussion on the challenges of simulating social phenomena using an ABM. The chapter concludes with a review of different research approaches to modelling the behaviour of microfinance clients. To locate the content, please refer to the TOC below.

Contents

3.1 Types of Scientific Models

Models are central to science and appear in numerous formats. These range from physical representations (e.g. architectural scale models) all the way through to purely abstract mathematical specifications (e.g. models of theorem generalisations). The usefulness of each scientific model is closely associated with their type and area of application. Some scientific models intend to provide a theoretical representation, by means of implementing specific hypotheses. In these cases the intention is that, by testing the model, one ought to deductively contribute to either corroborate or falsify a theory by means of carrying out an experiment. Other types of models may simply intend to represent a particular aspect of a phenomenon to allow an inductive exploration regarding how assumptions and processes have been represented and implemented.

Despite the diversity of scientific models, they all are aimed at being somehow useful regarding the actual phenomenon, matching one or more of the following objectives: interpreting or describing data (e.g. quantitatively or qualitatively), testing interventions (e.g. deductive experimentation or inductive exploration), synthesising studies, forecasting (e.g. econometrics) and/or idea elucidation (e.g. demonstration) [Sarkar, 2013, Heckman and Vytlacil, 2007]. Thus the common feature amongst models is to:

"[...] provide a simplified representation, of what is known and relevant, that is somehow helpful to further understand, describe or explore the real phenomena [...] [Geweke, 2005].

One can then best understand the role of scientific models when thinking about them in terms of usefulness, rather than truthfulness. I.e., although a model may not be absolutely true[1] regarding the real phenomenon, it may still be useful to some degree regarding the real system. This is typically the case of simulation models, which often only implement what is of apparent relevance to be experimented with. A comparison between the variety of approaches to simulation is introduced on the next pages.

[1] In terms of a model being, representation-wise, fully accurate, correct and complete.

Table 3.1 below illustrates the most important different simulation approaches and their general features. Each one is reviewed based on how different it is from another in terms of the simulation level, possibilities for communication and scalability in light of complexity. In every approach, researchers can compare the feasibility of obtained results with data that has been collected from a real-world scenario. That is what happens in case there is comparable data from the target phenomenon. Yet a unique advantage of an ABM simulation model is that some can provide a generative approach [Gilbert and Troitzsch, 2005, Epstein, 2006]. That is, those simulation models that are based on the continuous interaction between entities can generate outcomes that one is unable to completely foresee prior to running simulations. Therefore if one is interested in the interaction between entities, the agent-based approach is the most flexible.

Approach	**Simulation**	**Interaction**	**Complexity**	**Scalability**
Equation-based	of macro aspects	agents are isolated (no comm.)	either linear or non-linear	numerical processing
Discrete queueing	of micro aspects	a representative agent or none	dependent on timing scheme	depend on input data
system dynamics	single entity composite	no interaction is needed	simple agent, complex world	environmental relations
Micro-simulation	focus on a group or task	isolated agents, maybe parallel	may include social actions	group segmentation
Cellular automata	inter-group influences	neighbourhood dependent	simple and distributed	according to a matrix
Neural networks	depend on sensing cells	discrete and between layers	depend on layering schemes	training dependent
Learning models	statistical mechanics	no agent interaction is needed	depend on types of data	data-set dependent
Multi-level	intra- and/or inter-group	no agent interaction is needed	flexible levelling setup	computing power
Agent-based	multi-entity interaction	either direct or indirect	agent architecture is flexible	computing power

Table 3.1: Different approaches to social simulation, updated from Lucas [2007]

Computational simulations, including the agent-based approach, are models that require implementation using programming languages. Simulations offer mediation of knowledge development between theoretical approaches and experimental (or empirical) approaches to research a social phenomenon [Frigg and Reiss, 2011, Guala, 1998].

Analytical models result in data that is directly dependant on the input, which is made of a parameters are set, and one is typically interested in this approach for optimisation purposes. Finding an optimal solution may be computationally very demanding, leading to significant delays in processing a model, so simulations are often used to speed-up this process. As there are various abstraction levels for simulations, one must understand the necessary level of systemic granularity (i.e. the amount of detail that one should model) [Remondino, 2004]. Hence there are four main approaches to simulation:

- Discrete Events: these consist of systems with global rules and local dynamics, which are due to entities passively reacting by transitioning from one internal state to another [Banks et al., 2009]. A model of this type consists of flowcharts describing how data and resource flow between the specified entities. These are passive and go through processes such as queueing for processing, seizing and releasing resources. Due to the general purpose, discrete event models have become popular in niches where the structure of processes are essential. These include, for example: business services, manufacturing and logistics [Choi and Kang, 2013]. Hence modellers using this approach have to define an algorithm that takes into account the global process through which entities will be processed.

- Dynamic Systems: these consist of systems modelled mathematically based on continuous variables that are based on physical measurements or theoretical experiments [Wolkenhauer, 2001]. These include, for example, those related to kinematics (i.e. the mechanical features of motion *prior* to being exerted over an entity) and dynamics (i.e. the mechanical features of motion *while* being exerted over an entity): location, velocity, acceleration, pressure and density. Due to the precise nature of this approach, most focus is on understanding the causal structure of the phenomenon of interest [Hanneman, 1988]. The variety of linear and non-linear mathematical motions explored and explained by dynamic systems includes a wide range of dynamics such as chaotic and bifurcation trajectories [Zhang, 2006]. The successor of this approach, System Dynamics, is based on simplified principles of dynamic systems and is discussed on the next page.

- System Dynamics: deals with aggregates at the highest level of abstraction, as there are global rules and global dynamics (i.e. a top-down approach) [Meadows et al., 1974, Rowell and Wormley, 1996]. Flows of information, between entities in the system, are controlled by a set of equations that can lead to positive (i.e. reinforcing) or negative (i.e. balancing) loops. These concepts have been adapted from theories of physical systems, regarding their control and dynamics, so that could be applied to management. A system dynamics simulation is concerned with the interconnection of the model components that work and affect each other. That is as one can explore linear and non-linear dynamics at the aggregate level, aiming at exploring the whole system and predicting effects within it. For this reason there is no communication between components, but data points that aggregate at different rates. That is thus a reductionist approach that is fully dependent on how the model components are mechanically interconnected.

- Agent-Based: can deal with all levels of abstraction simultaneously, as it consists of active individual entities with local rules and local dynamics (i.e. a bottom-up approach), which generate macro outcomes (i.e. based on their aggregate) [Gilbert, 2007]. An ABM then is a formal representation of a real phenomenon, in the form of a computer program, with the goal of: a) describing the target system more precisely than with non-discursive languages and b) allowing experimentation with the simulation model [Moss and Edmonds, 2005]. The ABM approach allows to tackle the complex interplay of multiple social processes through the analysis of results obtained from the interaction of heterogeneous entities. This enables researchers to explore trajectories both at the macro (i.e. system-wide) and micro (i.e. individual entity) levels. Such departure from the more traditional mathematical simulation approach, such as system dynamics and dynamic systems, is significant. A further key advantage and difference regarding ABMs, is the ability to incorporate both quantitative and qualitative evidence in the model [Gilbert and Troitzsch, 2005, Epstein, 2006]. These capabilities are the essential rationale for having chosen this approach to further understand the social phenomenon of interest in this research project.

3.2 Agent-Based Simulation as a Scientific Model

Due to the flexibility of ABM discussed in the previous section, one can conclude that such approach is appropriate to deal with middle range theories. I.e. those with a context-specific limited set of assumptions from which hypotheses are drawn from [Wallace and Wolf, 2005, Merton, 1967]. That is not the case for functionalist, grand theories that are all-encompassing and wide-ranging. It is also not the case with empiricist approaches derived from logical positivism, which emphasise data analysis without theoretical constructs [Burns, 2009, Pedhazur and Schmelkin, 1991]. To better understand this difference, a clear definition of the functionalism theory is given below:

" The analysis of social and cultural phenomena in terms of the functions they perform in a sociocultural system. In functionalism, society is conceived of as a system of interrelated parts in which no part can be understood in isolation from the whole. A change in any part is seen as leading to a certain degree of imbalance, which in turn results in changes in other parts of the system and to some extent to a reorganization of the system as a whole. [...] functionalism was based on the model of the organic system found in the biological sciences. " [Theodorson and Theodorson, 1969]

This macro-sociological approach is characterised then by the overall concern about understanding the structure, nature and balance of the interdependence between organisations. The numerous difficulties of proposing and accurately testing socio-behavioural hypotheses, regardless of whether these are based on grand or middle-range theories, can be ameliorated by the requirements imposed by the development of evidence-driven ABM simulations. That is because such simulation models require a greater precision (i.e. clarity and non-ambiguity) to computationally represent the assumptions and process that have been empirically-grounded. This process can thus contribute to clarify observations guided by the principle of middle-range theories that have been empirically grounded [Gilbert, 2008, Kuorikoski, 2010, Squazzoni, 2012].

Various approaches to model and simulate social phenomenon are becoming increasingly popular as research approaches, especially in academia, but also –to a lesser extent– in industrial and commercial environments. In this sense, particular attention has been given to computer science agent technologies for building ABM [Luck et al., 2005]. Besides criticism to over-simplifications found in models strictly based only on keep-it-simple principles, many are still developed without guidance provided by experimental or empirical evidence [Axelrod, 2005, Edmonds and Moss, 2005]. For an ABM modeller of a social phenomenon, it is essential to consider that social behaviour is subject to influences that are only well understood with detailed knowledge about the phenomenon in question. This is usually attainable with non-experimental data, yet there is a growing number of cases where experimental data is also at hand. Many abstract models use plainly unrealistic assumptions to represent structure and processes of social behaviour, a fact that further complicates cross-validating models at macro and micro levels [Moss and Edmonds, 2005, Gilbert, 2007, Moss, 2008]. Such practice is particularly evident when modellers use personal estimations to justify arbitrary implementation decisions and configurations. These difficulties arise due to the unavailability of datasets about social phenomena. Hence datasets often are:

- (a) non-existent, thus requiring funding to collect and process information;
- or (b) unavailable due to privacy agreements, such as in non-disclosure clauses;
- or (c) if at hand, the description of processes or subjects is incomplete or outdated.

Research in this area must overcome sizeable barriers in devising methods and resources to systematically collect data for improving representations of social behaviour, which also guide the modelling of ABM aimed at stakeholders and policy-makers. Another significant issue is the general neglect in the research community regarding security of potentially sensitive data. This includes non-standard procedures employed in data collection, analysis, storage and the responsibility modellers may need to emphasise the present-day relative incipience of validation methods for assessing their own results obtained in social simulations [Moss and Edmonds, 2005, Gilbert, 2007, Moss, 2008].

There are no established standards on what is acceptable quality in terms of using behavioural data for informing social simulation research. Coding of non-anonymised qualitative data and attributes, collected in questionnaires, oral interviews, mailing lists, online forums or social networking databases is to some extent arbitrary –as this often completely relies on the coder. At best institutional recommendations are in place, but these usually do not address data provided to and derived from ABMs.

The theoretical potential of social simulation models seems, at least to some degree, overshadowed by their foreseeable disadvantages [Boero and Squazzoni, 2005, Bankes, 2002, Lucas, 2011, Edmonds et al., 2013]. This is crucial, as there have been various suggestions that ABM could support, or even guide, decisions and policy-making. This might be possible with aid of a full-time, in-house and experienced modeller working in close liaison with stakeholders and policy-makers. Yet this is unlikely to be successful if inexperienced users are expected to cope by themselves with the common limitations of running such simulations and interpreting its results. The aforementioned difficulties, along with the multi-disciplinary historical factors that have been continuously shaping the inter-disciplinary field of social simulation, have contributed to a *status quo* that:

- (i) is lacking an effective *de facto* development-cycle methodology, focused on producing results that somehow are potentially useful beyond academic theories,

- (ii) has piled criticism on the numerous social simulation models, including ABMs, that bear little relation to the actual social phenomenon in question.

It has not yet been possible to produce, through ABMs, useful predictions of the consequences of simulating specific policy options. Moreover, non-academics understand the commercial and educational contributions from Artificial Life software (henceforth ALife) and other game-like simulation models. Yet there is a much greater difficulty in realising what are the non-theoretical contributions that one can obtain from an ABM.

Implementations that successfully fulfil commercial or educational purposes abound, but none of these are really intended to contribute with results of wider stakeholder or policy-maker interest. Notable examples include: various online role-playing communities such as Maple Story [Pearce, 2009], ALife educational models like Noble Ape using neural networks (discussed in [Lucas, 2007], Chapter 4: "Emotion and Social Interaction"), artificial evolutionary biology in Tierra [Swan, 2009], games similar to The Sims [Martey and Stromer-Galley, 2007] and virtual environments such as Second Life [Ritzema and Harris, 2008]. Although agent-based research has been gradually consolidated as an alternative to traditional social and economic science methods, to date, no example of an ABM could be found that has provided direct contributions to policy-makers or stakeholders [Edmonds et al., 2013].

This lack of policy relevance is perhaps the most important open problem affecting the credibility of social simulation research in other domains. Non-academics tend to appreciate the direct potential of ABM, as a third way of doing science [Axelrod, 2005]. Yet these same people can point out that an ABM may not directly improve their understanding of actual, non-virtual social phenomena beyond illustrating theoretical hypotheses that require further evidence for actual validation. Simulation models oriented towards entertainment or exploration purposes are most likely the only –if any– software similar to ABM that non-experts have used. Further to this, it is also commonly known that simpler, theory-driven models tend to be made fully and freely available by authors than richer, more complex ABM. Despite noteworthy progress in the development of evidence-driven[2] and participatory social simulation modelling methodologies[3], impact on the wider non-academic community is negligible. In this sense, it is important to notice the subtle, yet fundamental, distinctions between ABM simulations built with methodologies that are driven mostly by evidence (qualitative and/or quantitative) and those ABM development approaches that are driven mainly by theory.

[2] I.e. qualitative and/or quantitative data-driven ABM development, such as the proposal discussed in Section 4.3: Evidence-Driven Approach to Modelling (EDAM) (page 86).

[3] I.e., involving stakeholders throughout modelling, implementation and validation processes.

The aforementioned approach tends to guide the modelling process through direct observation and data analysis (experimental or not). Thus the fine-grained decisions on how to computationally represent detailed aspects of a social phenomenon depend on the quality and reliability of the available evidence. An advantage of this approach is that modellers can discuss and evaluate their decisions more directly with the stakeholders. Conversely the latter aforementioned approach would mainly involve building representations using existent academic theories, which are often not fully grounded on data and require a significant amount of adaptations to allow implementation using a computer language.

When access to stakeholders is unavailable, it is no longer possible for the modeller to justify assumptions for building an ABM as having been validated by stakeholders. In other words, the modeller would need to decide –based on his/her own understanding– which of the conflicting-yet-feasible interpretations of the qualitative data would best represent the social phenomenon, or social process, in question. Ultimately it is the technical limitations of the chosen platform for implementation that will influence what and how the simulated social structures are computationally represented and processed.

To some extent then, both evidence- and theory-driven[4] ABM representations are subject to the simplifications demanded by the technical limitations of whichever software framework the modeller has chosen to work with. Another consequence is that simulation results can differ substantially depending on the precision of replication efforts [Lucas and Payne, 2014] and whether guidance has been derived mainly from evidence[5] (quantitative and/or qualitative) or theory [Gilbert and Conte, 1995, Moss, 2008]. On the other hand, evidence-driven approaches tend to direct ABM modellers towards using a more up-to-date and a multi-dimensional understanding of the social phenomenon. That is because the stakeholders participating in the modelling process can be directly accessed to strengthen the validation of qualitative data interpretations, which are needed to build and understand an ABM that is being grounded on evidence.

[4] Please refer to Section 3.2.1: Different Approaches to Build an ABM Simulation (page 58).
[5] I.e. experimental or non-experimental data about the phenomenon of interest.

3.2.1 Different Approaches to Build an ABM Simulation

Given the flexibility of the ABM research framework and implementation tools, it is possible for researchers to accommodate radically different development approaches and methodologies in the process of building a simulation model. As a consequence of this, one can find various examples of models developed either by being mainly theory- or evidence-driven (qualitative and/or quantitative). ABM can thus be interpreted as belonging either to one or another approach. The earliest approaches to ABM were undeniably theory-driven, as that is how the research area begun: providing a computational alternative for experimenting with sociological theories or hypotheses that could not be experimented with in actual settings. This is illustrated by [Alam, 2008]:

" A major reason behind the scant presence of available evidence-driven agent based models is that such models require the modellers to engage deeply with the evidence. The model's assumptions and the results must be taken back to the experts and also stakeholders iteratively during the whole modelling process. Understandably, modellers' access to the evidence is constrained by limited availability of resources in developing descriptive bottom-up models. This is in stark contrast to ad hoc or prior theoretical models based on the modeller's speculations about social reality. "

Hence in an attempt to improve the *status quo*, researchers in the ABM community seem to be increasingly motivated towards developing simulation models that are grounded on existing empirical or experimental evidence, rather than just theory. Due to the nature of socio-economic phenomena, ABM modellers certainly have to confront the inherent subjectiveness that accompanies the task of representing –unambiguously, as it has to be implemented computationally– the relevant social structure and process. To code these, one will have to use a non-discursive and precise notation, that is: a programming language.

There is no *de facto* standard to evaluate and validate an ABM, despite proposals put forward to document agent-based models in [Grimm et al., 2010] and [Polhill, 2010]. Provided there are enough resources and time, modellers can experiment with different implementation methods in search of the most successful approach to develop an ABM. As this would be very time-consuming, it is likely that only one methodology, algorithm and modelling language will be fully implemented. And that is probably the one which the researcher has most experience with. Generally, a different coding approach is tested only when the ABM is being replicated. This is important in the modelling lifecycle of an ABM as such challenges recur within the processes of data collection, analysis, interpretation and implementation of qualitative information [Given, 2008]. This is also crucial in ABM because observable social behaviour, i.e. that with potential to be modelled, may not be strictly conditioned by the observable circumstances.

The relevance of representing accurately, say the geographical features, in an ABM depends directly on what one aims to simulate. For instance, Land Use, Land Cover-Change and transportation models[6] aiming at informing policy-makers require superior accuracy and credible geographical representations, along with an appropriate corresponding behaviour than more abstract simulation models. These types of models tend to render themselves inadequate for policy-making purposes. A good way to highlight what is important to model as an agent-based simulation is to analyse quantitative and qualitative data about the specific phenomenon of interest.

[Shapiro, 2007] discusses the importance of using a similar result-driven approach (in this case, problem-solving) to guide one whilst deciding what is the most appropriate sociological method to employ. Therefore, in this sense, both quantitative and qualitative data are absolutely necessary bearings for agent-based modellers to further understand the phenomenon in question.

[6] See discussion in Section 3.2.2: "Challenges in Simulating Social Phenomena with ABM" (page 65) and Section 5.4.2: "Modelling Guidance and Impact on Policy-Making" (page 163).

The importance of pursuing development of new knowledge about the actual social phenomenon, and not only about the social simulation model itself, is what warrants the proposal of a development lifecycle that is thoroughly evidence-driven (i.e. involving qualitative and/or quantitative data). Such approach to develop an ABM shall be one of that requires: the selection of assumptions, justification of implementation decisions and then validation of results to be mainly backed by the existing data, which has been sourced from the social phenomenon participants and not just theoretical conjectures.

In this regard, it is important to consider the roles of how inputs of different types and qualities of data can influence the modelling process and results obtained in social simulations. This is crucially relevant for agent-based modellers, as the prevalence of implementation platforms based on object-orientation has clearly facilitated the incorporation of heterogeneity into agents. Both in terms of behaviour and the integration of different types of data structures into the simulation model. This means that the agents can be autonomous entities, which may be individually different from each other, both from their behaviour and data input perspective. This adaptability of ABMs is a considerable advantage as it allows the interaction between different, coexisting agents within one model and the integration with other models if deemed necessary. Due to the steep increase in complexity involved in analysing nested models[7], modellers interested in informing policy-making with simulation results tend to refrain from this.

Fully theory-driven approaches for building ABM present a tendency to detach the modelling process from data, if at all analysed by the modeller, about the actual social phenomenon. This is because it is often difficult to collect –or access– up-to-date quantitative and/or qualitative datasets about non-virtual and virtual social phenomena. Complete –or good enough– behavioural data may sometimes be unattainable. Yet if at hand one reckons that analysing such information would account for a description of the dynamics registered in past events.

[7] Discussion in Section 4.3: "Evidence-Driven Approach to Modelling (EDAM)" (page 90).

For that reason, ABM modellers always require a balance between how much theory and how much available evidence shall drive the development of a simulation model. In this spectrum there are development methodologies which gravitate towards being exclusively theoretical (such as some used for particular computational economic models [Tesfatsion and Judd, 2006]) and others, rather at the other extreme, which require extensive stakeholder participation (such as those ABM developed using the companion modelling approach) [Bousquet et al., 1999]. In this regard then it is worth mentioning that my experience in building ABM has suggested a productive emphasis onto the collection and analysis of evidence (quantitative and/or qualitative), over purely theory-driven approaches. In this way, there is a facilitation of how developers can validate the modelling process itself, as discussed in detail by [Moss, 2008].

3.2.2 Challenges in Simulating Social Phenomena with ABM

It is paramount to understand the usefulness and implications of research intending to use ABM models beyond theoretical, hobbyist or educational purposes. For that, it is necessary to confront unresolved issues surrounding the design, development and testing of such simulations. E.g. it is key to understand the recurring issues that both theory- and evidence-driven –qualitative and quantitative– modellers face whilst collecting, analysing and translating data into social simulations. Thus this section contains a discussion on the ongoing momentum in the ABM research domain to improve some of the longest-standing methodological issues regarding the development of social simulation that ought to be useful beyond theory. Some recommendations are put forward in Section 4.3: "Evidence-Driven Approach to Modelling (EDAM)" (page 86) following the evidence gathered for this research thesis: from literature, surveys and interviews.

As a preliminary gathering of data, 12 leading academic researchers –each of them having managed at least one mid to long-term (three to five years) social simulation projects in Europe and the United States– have been interviewed [8] regarding how their endeavours were modelled, applied and whether these have been useful beyond theory. The administered questionnaire consisted of eliciting their views with these questions:

- (I) How were fieldwork findings used to guide the simulation development?,
- (II) What were the contributions of simulation results to stakeholders?,
- (III) Were simulation results regarded by them as useful as fieldwork findings?,
- (IV) What could have improved the chances of providing these via simulations?.

Three businesses offering ABM which take into account social behaviour were also approached, but all organisations refused to participate due to non-disclosure agreements.

All surveyed researchers mentioned that ABM targeted the scientific community and could, at best, provide plausible results regarding scenarios that, albeit coherently built, no simulation result could be regarded as directly useful for policy-making purposes. All (12) cited that gathering detailed data about the actual phenomenon by interviewing stakeholders and reviewing existent literature helped them to properly understand their context and served as a good guide during the modelling process. More than half (7) mentioned that stakeholders and policy-makers were not interested in the ABM *per se*, and only that real success cases (even those with only anecdotal evidence) are what they would take into account. A few (3) mentioned that ABM, despite being pragmatically unusable by end users, attracted great interest from stakeholders and policy-makers, but regarded the modelling process itself as time-consuming –and at times unproductive.

[8] Data was compiled until July 2009, on time for discussions at the 6th European Social Simulation Association Conference in September, then updated for the AI & Society Journal.

The aforementioned findings contrast with the generally positive experience with fieldwork. Despite demanding much time, the majority (10) confirmed that it was useful to acquire knowledge regarded as relevant to the practitioners[9]. Directly engaging with stakeholders and policy-makers was interpreted by all (12) as indispensable to improving their understanding of the actual social phenomenon. Yet maintaining an efficient interaction and management of the practitioners' interest over months of work engagement was equally deemed strenuous and difficult[10]. Some (4) of the surveyed subjects cited that ABM perhaps could be integrated in tools for mediating group decision-making. Being confident about model results was another aspect raised by all (12) interviewees, along with difficulties of coding and interpreting qualitative data appropriately[11]. Being able to communicate the model itself, and its results, in an easy and intelligible way to a non-technical audience has also been mentioned as a challenge by all interviewees. Some (6) of the surveyed subjects mentioned that their focus was to theoretically model a social phenomenon in a plausible manner, without intention to influence it.

After submitting the preliminary version of [Lucas, 2011] on January 5th 2009, an email by Scott Moss was sent on April 28th to the mailing list for computer simulation in the social sciences (henceforth SIMSOC) entitled "any correct policy impact forecasts?". As it can be seen in the mailing list Web archives[12], until 30th June 2009 there were more replies from authors, based in more countries, than my survey presented in this section. Even with worldwide replies, no single example of a ABM that has been useful prior to policy implementation could be found. Though insightful discussions followed in SIMSOC, including the threads: "Merging at the edges", "what is the point?" [of modelling] and a follow-up, "The point and the process" and "Purpose of Modelling".

[9] The remaining two did not administer any fieldwork or other similar *in situ* studies.

[10] This finding is supported by other, larger research projects regarding the collaboration between policy-makers and researchers such as [Segone, 2008, Young and Mendizabal, 2009].

[11] See [Mauthner et al., 2002, Given, 2008] for some descriptive examples of these issues.

[12] Archives are available online at this address: www.jiscmail.ac.uk/lists/simsoc.html .

Note that this is not necessarily tied with the idea of usefulness limited to numerical forecast or prediction, as the challenge remains open: to provide useful results beyond theory about the actual social phenomenon –and not simulation models themselves– directly by interpreting the ABM results.

As stated in my SIMSOC reply on 11th June 2009, all academic discussions I have engaged since May 2008 with researchers on issues surrounding the usefulness of ABM yielded similar conclusions in terms of what has been done so far beyond theory with this type of simulation model. This issue does not only depend on validation, as the actual focus is to strive for further understanding on how and when ABM may be pragmatically useful. I have also emphasised in my post the value of further exploring issues, which are recurrent in different domains, on how real policies are discussed, implemented and evaluated[13].

Policy-makers would wish a way to reliably predict and forecast as their most desirable outcome of a simulation model. That is evident, as it would be their ultimate tool: to allow the reliable testing of hypothetical scenarios. However such ideal is rather implausible with the current ABM state-of-the-art, and depending on the nature of the social phenomenon this goal may remain wholly unachievable –regardless of the deployed simulation approach.

It is difficult to understand how exactly a social phenomenon can influence the political process of policy-making. There is a great variety of influences and agents, so unless social circumstances are very similar, analyses of how past case studies have developed is likely to be ineffectual in assessing new scenarios [Taleb, 2007].

[13] For other examples, please refer to the Overseas Development Institute program entitled Research and Policy in Development at www.odi.org.uk/programmes/rapid and International Development Research Centre (IDRC) online publication: Knowledge to Policy [Carden, 2009].

These peculiarities hinder accuracy and plausibility of simulation models, as previously relevant knowledge backing the implemented assumptions, may simply no longer reflect reality. Simulation models that depend heavily on physical aspects, such as Land Use, Land Cover-Change and transportation are currently the best contenders to provide useful results beyond theory. This is because, in these cases, the repertoire and scale of possible social behaviour is heavily constrained, particularly in terms of the circumstances regarding their occurrence and possible development. These features force a strict framing of the social phenomenon during the modelling process, and this reinforces the requirement for accurate –or at least highly realistic– representations of what can happen in these simulation models.

However if geographical or physical aspects are largely irrelevant to the social dynamics in question, modellers must consider a much broader set of plausible cognitive aspects when modelling individual behaviour. This happens as the total scope of tenable behaviour-to-be-modelled can expand dramatically. In such cases, the nature and constraint of plausible behaviour may be little understood and thus rather difficult to model plausibly. That is when access to empirical or experimental data can be very helpful to guide the development of an ABM.

Despite general stakeholder interest in ABM, those with influence over the phenomenon in question tend to be cautious in using results obtained from such models. As discussed later in Chapter 5: "Research Findings"[14] (page 100), it is unclear what can be done with data obtained from ABM that cannot be objectively compared with existing evidence. For example, when a completely unprecedented scenario[15], is suggested by a simulation model. In these cases, setting apart what is really relevant to be modelled, from what is not, may be indeed a *catch-22* for modellers. Similar arguments in this regard have been put forward elsewhere, such as by [Bankes, 2002] and [Gilbert, 2009].

[14] Also highlighted on the poster in Appendix V: Usage of Agent-Based Models (page 204).
[15] That is, lacking data that is at least qualitatively similar to any comparable case study.

If compared to simulation models, commissioned fieldwork has greater chances of being useful in a timely fashion, as it is feasible to provide more up-to-date reports about specific aspects of the actual socio-economic phenomenon. Experience, including the survey previously discussed, backs up the fact that insights obtained in fieldwork analysis are often clearer to understand and act upon than simulation results. In this thesis, issues raised via fieldwork were directly related to events that were still occurring in the MFI. Hence stakeholders and policy-makers could quickly recognise the value and implications of that new knowledge. Simulation models tend to operate on much longer, or hypothetical, time scales and this invariably creates difficulties to interpret potential inaccuracies. This is perhaps the strongest pressure for methodologies that systematically embed validation steps throughout the development process of an ABM.

Furthermore, with the exception of participatory and immersive-augmentative simulations, evidence-driven (i.e. qualitative and/or quantitative data) modellers work with sensitive data about the subjects of a social phenomenon. Not much guidance is available about this, as only one code of ethics specifically targets research using simulation models –such as ABM [Ören et al., 2002]. In it, items 2.6 to 2.8 address the professional issues arising from the rationale that modellers are responsible for clearly presenting the applicability of their simulation and interpret the results in light of verifiable evidence [Ören, 2002].

To date none of the following research associations had a single institutional document online regarding research ethics. This includes the: European Social Simulation Association, North American Association for Computational Social and Organization Sciences and Pacific Asian Association for Agent-based Approach in Social Sciences. The Journal of Artificial Societies and Social Simulation , since its first volume in January 1998, has only one paper –which is [Conte and Paolucci, 2004]– that tangentially relate ethics, responsibility and accountability, but of agents and not modellers.

3.3 Modelling the Behaviour of Micro-finance Clients

Whilst there are different approaches to modelling the behaviour of microfinance clients, most are econometric or game-theoretical and are not focused on interaction aspects of social collateral in microfinance [Rodriguez Meza, 2000, Vogelgesang, 2007, Karlan, 2007]. Even more limited are the few existent agent-based approaches to microfinance. Despite the growing interest in the industry to better understand social aspects of microfinance [Sinha, 2006, CGAP and EU/ACP, 2008], these have either been implemented as a proof-of-concept[16] or are focused on financial aspects of the industry. The discussion that follows in this section concerns examples of existing approaches, both ABM and non-ABM, aimed at modelling and simulating aspects of microfinance.

Neoclassical econometric approaches typically propose linear models that are tested using variations of the Ordinary Least Squares (henceforth OLS) regression, which includes a strong assumption that regressors are fully exogenous and contain no multicolinearity[17] [Greene, 2011]. One example of this is given by [Gomez and Santor, 2001], based on the hypothesis that social capital[18] is a determinant of the success of individuals funded through the Calmeadow Metrofund, the biggest SE operating as a MFI in Canada. In this example, cross-sectional survey data is analysed along with the MFI administrative files – and findings include: (a) that individuals with little or no financial collateral can benefit from increased levels of social capital, and (b) a theoretical basis that certain environments where microfinance clients are based can lend itself better than others depending on their type of business. The combination of socio-economic data to account for social and financial measures, along with controls for neighbourhood and individual properties, is the popular OLS method for linear estimation to statistically model and describe microfinance [Ledgerwood et al., 2013].

[16] Online examples include a 2005 NetLogo's library entry "Economic Exchange", and a subsequent extension of that version in "Microcredit in Bangladesh" term-time academic project.
[17] I.e. two or more predictors being correlated, so that one is linearly predicted from others.
[18] In the sense of a network of relationships and neighbours to facilitate individual action.

Another rather different, yet nevertheless popular, approach to model microfinance is to apply game-theoretical concepts. [Rajeev et al., 2006] for example proposes to model the decision-making of individual borrowers as to either one should become an entrepreneur in a relatively risky project or in a relatively safe project. In this type of approach, individual trade-offs are analysed in terms of characterising degrees of profit probabilities attached to each decision option. In this case, it is assumed that clients will only be able to repay credit when their individual projects are successful. This is based on the assumption that traditional credit funding frameworks should encourage the uptake of the safest, best-suited service to each client. This, in microfinance, would offset the fact that MFI schemes work with measures of joint liability within groups to help them to indicate when riskier projects may be a good idea to fund due to the collective nature of credit repayment. This is a common feature amongst MFIs.

[Gine et al., 2010] provides a similar discussion in this regard, but with a model that is focused on just one representative borrower and lender. I.e. the supply-chain market is assumed to converge towards an equilibrium. In game-theoretical models, such as the one discussed in the previous reference, one can calculate all the possible solutions, so that one can aim at predicting how an iterated version of the design can be analysed. This was useful to provide insights into investment decisions over time as a payoff matrix that describes every feasible result in light of every client's possible joint liabilities. According to the first aforementioned reference in this page, the designed game has been played 27 times by hundreds of actual MFI clients during seven months in Peru. Results have been used to draw hypotheses and questions about loan features, such as that group lending can induce moral hazard[19] instead of reducing it. That is, in absence of institutional (i.e. top down) incentives for one to guard against collective risks[20], certain institutional policies can in fact hinder –if not altogether preclude– the positive (bottom-up) effect of assortative matching[21].

[19] In this case, this relates to one person's inability to evaluate the consequences of whether another peer in the group can indeed keep up with his/her credit entrustments over time.

[20] E.g. when a MFI framework does not allow participants to form groups by themselves.

[21] This is also discussed in 5.2: "Fieldwork Findings: Microfinance Clients (page 130).

Another research project has investigated experimentally whether the existence and strength of family ties yield differences in repayment performance [Carillo, 2010]. This took place with microcredit groups in the Mexican state of Oaxaca and consisted of 23 sessions, during three weeks between September and October 2009. Different game configurations collected data from 143 participants who were all clients of a local MFI. Each person was given a loan and needed to decide on investing either in a risky or safe project. Two versions of the game were played: with and without family members in microcredit groups. This concluded that individual behaviour in groups composed by family members demonstrated safer behaviour (i.e. better repayment rate) than those groups without family members. Another reference, [Abbink et al., 2006] provides a similar game-theoretical discussion in this regard, yet with focus on how profit can be maximised.

A different study, involving 140 groups from Burkina Faso suggests that greater homogeneity amongst members in terms of ethnicity, occupation and income reduce financial performance [Paxton and Thraen, 2003]. Yet another analysis, of 102 groups from Eritrea suggests that monitoring and social ties of group leaders can reduce moral hazard between lenders and borrowers (i.e. the group repayment performance depend on the group leader) [Hermes et al., 2005]. Another analysis, of 128 microfinance groups in Bangladesh [Sharma and Zeller, 1997] and 262 in Thailand [Ahlin and Townsend, 2007], suggests that issues related to repayments tended to increase according to the number of relatives in the respective groups.

Another type of modelling is best exemplified by Microfin, which is a project funded by the Consultative Group to Assist the Poor[22] (CGAP) since 1997. This is a essentially a Microsoft Excel template that has been developed to facilitate the management of a MFI, including tasks of business planning and financial modelling [Lunde et al., 2006].

[22] A microfinance international consortium of public and private development organisations.

The latter feature results in a five-year financial projection, showing trend analyses based on actual datasets to aid financial decision-making. Examples include: the design of financial strategies that take into account services to customers, analysis of institutional capacity given the current available resources, monitoring of activity levels in marketing and projected financial statements. One acclaimed feature, both for training and management (operational plus financial) purposes, is that it allows the following:

" [...] the user to test out the financial consequences of implementing different management decisions, such as increasing loan sizes vs. increasing the number of borrowers, or raising interest rates vs. cutting operational costs [...]"
[Waterfield and Sheldon, 2004].

Despite its considerable success in the microfinance industry, one big disadvantage of Microfin is that is is dependant on proprietary software. The continuous cost of maintaining the Microsoft Office software license agreement is not negligible to many MFIs. Moreover every officially supported operating system for this package is also proprietary, which means further indirect costs to use the Microfin template reliably. That is due to the Visual Basic For Applications[23] requirement to run Microfin macros that implement various of its functions, such as calculation of the transaction costs. Nevertheless Microfin is to date still one the most popular software used by MFIs worldwide, as it serves them trust-worthily both for financial management and extrapolations.

The need for more flexible and cost-effective systems has given rise to a number of alternatives. Perhaps the most prominent example is the 2006 Grameen Foundation's Technology Center initiative to develop the multi-platform Micro Finance Open Source[24] Software (henceforth MIFOS) framework, which allows modular addition of functions[25]. Both Microfin and MIFOS allow simple financial simulations based on statistical extrapolations.

[23] An event-driven programming language designed to automate internal program processes.
[24] I.e. the source-code is officially copyrighted but still made freely accessible to any user.
[25] E.g. such as financial forecast, banking protocols or PPI plug-ins [Campion et al., 2008].

Another type of MFI-related simulation is embodied by Symbanc[26], which is a software first developed in 2004 using system dynamics with the Vensim platform [Hirsch et al., 2005]. This modelling approach is focused on analysing the complex interactions between the proposed internal timings and feedback loops, between key variables, which are intended to either reinforce or reduce the intensity of causal links between the Symbanc modules. These are broadly depicted in Figure 3.8 below. To use it, the user has to configure various financial parameters (such as target market and nature of products) and then the simulation model can be executed to generate a financial trajectory of the MFI. In other words, it allows the testing of financial limits according to a set of initial conditions in a system dynamics model.

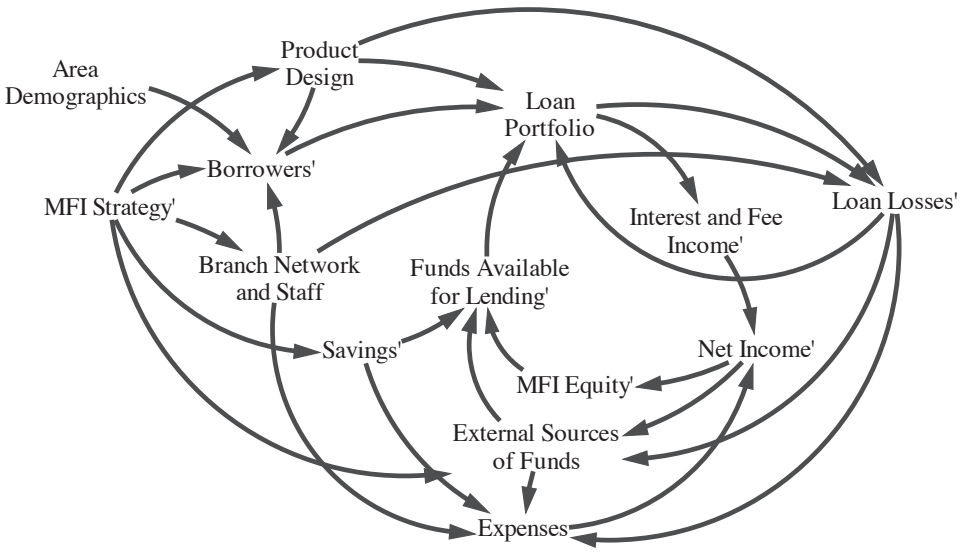


Figure 3.8: Symbanc feedback loops, source: [Hirsch et al., 2005]

The total number of borrowers (left hub) depend on: the strategy set for defining a target market, area demographics, conditions of offered loan services, extent of the MFI branch network and a staff-experience ratio. The loan portfolio (middle top hub) growth depend on the left hub and the combination of internal (earnings and savings) plus external (public or private donors) funders. As one can observe, the most connected nodes (i.e. those with both relatively many incoming and outgoing links) form various inter-dependent loops that change values over time according to the other modules.

[26] Despite a free online version provided by Harvard University, the source-code is proprietary.

The Symbanc model can simulate the finances of an institution up to eight years or until the institution runs out of money [Hirsch et al., 2004]. Therefore the focus of this simulation tool can be summarised as that of allowing a MFI to test their setup regarding the multiple financial trade-offs for setting up and managing a MFI . In doing so, the system dynamics model can illustrate some typical failure settings such as not having enough capital to support continuous and fast growth in the number of clients.

Neoclassical and statistical quantitative approaches to decision-making are, by design, normative[27] and not empirically grounded in terms of testing models with domain-specific datasets. These include the stochastic-dominance models, expected-value and expected-utility models, some of which are discussed in this section. Such models are based on the assumption that utilities can be calculated across the set of possible actions an individual or organisation has and then the best alternative is chosen or suggested for direct enactment. In this sense probit and logit analyses have two advantages over the aforementioned models [Pedhazur, 1982]: (a) they are statistically testable using either empirical or experimental datasets; and (b) the analysed trajectory choices of agents are those of several, rather than one individual. The major disadvantage of the neoclassical and statistical approaches is the rather unrealistic assumption of different weights being assigned to several variables. These are then tested in different combinations to determine which of several possible outcomes is –statistically– the best one. Although this is good for optimisation purposes, it does not capture the decision-making process itself. Thus these approaches may describe well the retrospective relationship between variables and, *ceteris paribus*, may provide insights into predicting behaviour. Yet the lack of heterogeneity considerably limits this type of modelling approach.

When one cannot rely on statistics about the phenomenon of interest, computational and rule-based approaches to modelling decision-making can be used to build simulation models that are based on less rigid assumptions than neoclassical and statistical models.

[27] Linear-additive such as the regression approach, aiming to test relationships and contributions of independent variables to explain variations in a dependent variable [Pedhazur, 1982].

The contrast with neoclassical econometric approaches is the grounding of a model on qualitative insights collected from the stakeholders. This allows the creation of a testable simulation model of decision-making based on data from individuals embedded in the same context and activity. In contrast to the abundance of econometric and game-theoretical models, there are few ABMs regarding behaviour of microfinance clients. And none of these have been developed based on empirical or experimental evidence.

For example [Rashid et al., 2011] proposes a high-level abstraction for testing the effects of implementing a MFI policy. It includes processes for changing the income level of clients and repayment ratio of microcredits over time. Agents have different behaviours that are broadly grouped as either poor or non-poor. Their interaction is bound according to a hypothetical grid, which influences behaviour such as: poor agents receiving credit from MFIs and economic activities of the non-poor from adjacent cells. The model tracks global variables in a similar way as the discussed Symbanc example. There is thus little contrast between these approaches[28]. Another preliminary ABM is proposed, but it is not implemented, which is the modelling of multiple levels for the regulation of the Mexican microfinance industry [Suarez et al., 2009]. This short paper contains a philosophical discussion, taking the Compartamos MFI as a loose case study to suggest that the structure formation within groups is driven by function-optimising clients and that this in turn depend on their collective behaviour. One more preliminary ABM is proposed, but it is also not implemented: multiple agents should belong to different socio-economic groups [Hoekstra et al., 2007][29]. Agents would then be equipped with spending, social, strategic planning and learning behaviours that would not be function-optimisations; but rather focused on allowing policy-makers to evaluate their own decision-making based on a bottom-up understanding of how money flows in the system and what are its multiplier effects across the participating entities. Another very abstract (i.e. not based on data), but implemented, ABM use pre-defined probabilities to configure behaviours regarding switches of: project success, strategy change (comparative or random), mutual repayment and group closure [Goldberg et al., 2004].

[28] This is because various agent-based frameworks allow system dynamics implementations.
[29] An initiative lead by the socio-economic development network Social Trade Organisation.

Summary and Conclusions of Chapter 3: Agent-Based Social Simulation

The chapter begun with a discussion on on the usefulness and types of scientific models, which includes a wide range of different approaches. This covered various approaches to simulation, with particular emphasis on four main approaches: discrete events, dynamic systems, system dynamics and agent-based models.

Next, a specific subsection on agent-based simulations discussed its role as a scientific model, along with the difficulties of obtaining relevant qualitative and/or quantitative datasets to guide the development of such a model. The different approaches, and challenges, to building an agent-based model have also been discussed in detail. Then the modelling of behaviour of microfinance clients has been discussed in terms of the following different approaches: neoclassical econometrics, game-theoretical setups, statistical extrapolations, system dynamics and the incipient attempts using agent-based models.

MFIs rely on a constant flow of information about their large number of small (often cash-based) transactions to effectively manage their financial operations. Success in this niche depends heavily on having experience and knowledge of the local market. This is not only a matter of quantitative information but also qualitative. This flexibility requirement makes the agent-based approach the most promising to take the available evidence into account in a way that one can further explore and experiment with. An agent-based model approach allows to tackle the complex interplay of multiple social processes through the analysis of results obtained from the interaction of heterogeneous entities. This enables the exploration of trajectories both at the macro (i.e. system-wide) and micro (i.e. individual entity) levels, which are based on the computational representation of potentially both quantitative and qualitative insights.

Chapter 4

Research Design and Development

This chapter contains an introduction and complementary discussions –listed in the TOC below– regarding the research design carried out to develop this thesis. These discussions range from the decisions on the cross-sectional approach to data collection, how each step relates to each other and the analysis of the compiled information from the MFI clients and credit officers.

This chapter also contains a discussion about the proposed evidence-driven approach for developing an ABM, a discussion with regards to the issues surrounding the integration of qualitative data in models and, finally, the structure of the developed ABM. The chapter begins with an introduction of the MFI case study, then it moves onto discussing what has been taken into account to develop the ABM simulation model.

Contents

4.1 The MFI Context during Data Collection

The MFI has been operating in the Chiapas state, Mexico (see Figure 4.9), for nearly 15 years (having started in 1999) and is a non-profit institution, which achieved financial sustainability after two years of having branched out of the Grameen Foundation using guidelines from the CGAP [Biggar, 2009]. In addition to micro-credits, the MFI also offers life and material insurance in cooperation with Zurich Financial Services, micro-savings plus educational and nutritional programs targeting mainly clients in rural communities. Credit officers are trained by the MFI to facilitate, using Spanish or one of the six languages of Mayan ancestry[1], to apply a financial approach to support the MFI social mission of alleviating poverty. This happens mostly through reinvesting the earnings obtained via the MFI periodic quota repayments and also the rather sporadic community-based or philanthropic donations that is also channelled to provide credit.

Figure 4.9: Chiapas, the southernmost state, adapted from [Cook, 2008]

[1] The MFI works with clients in Spanish, Tsotsil, Tseltal, Chol, Tojolabal, Zoque, and Mam. In this fieldwork, the officers dealt with: 44% Spanish, 42% Chol, 8%, Tzotzil and 6% Tzeltal.

The fieldwork centred in understanding what are the conventional social behaviour amongst members of micro-credit groups and whether it could influence their success. As traditional collateral are not used to assess new or further credit applications, the MFI employs a wide-range of socio-economic criteria to evaluate the collateral across the applicants. Social collateral is assessed according to each individual circumstances such as social affiliations and economic potential in relation to their local poverty line. Certain criterion can be waived by MFI if a client performance is known beforehand to the credit officer. As their actions are subject to economical constraints, both socio-economic and behavioural data were collected and analysed. Interpreting potential links between these was important to understand credit management at the group level from a social perspective. The fieldwork results served as a complementary source of information to understand how credit clients and officers deal with the MFI rules. The figure below illustrates where the 21 surveyed credit centres are geographically located (i.e. where clients congregate) and thus where the fieldwork data collection took place.

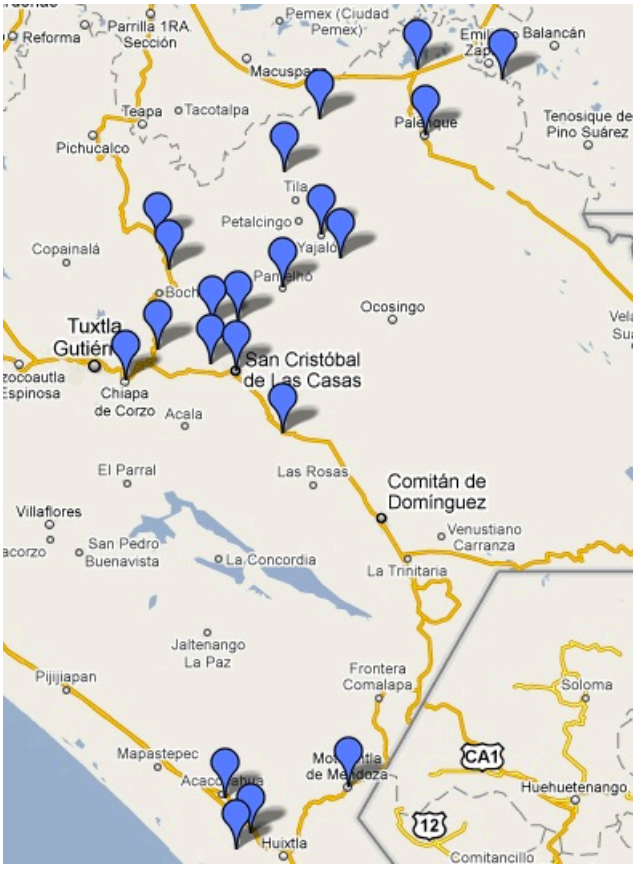


Figure 4.10: Raster KML[a] plot of the 21 client locations surveyed during fieldwork

[a] Google's Keyhole Markup Language (KML) for geographical visualisation and annotation.

4.2 Design of Data Collection and Analysis

To understand the roles of conventional social behaviour amongst microfinance clients, with particular regards to the MFI rules, fieldwork was carried out with the aim to collect and analyse financial and behavioural data on how participants of microcredit groups deal with their debt. The timely management of quota repayment by a MFI involves dealing with both individual and collective outstanding amounts. In case an individual has defaulted, there is a practical need for the group to decide whether another single individual or the group (wholly or part of it) shall take responsibility to repay the outstanding amount to the MFI. Although institutional rules state that the *group* is responsible for individual losses, yet in practice there are different ways to comply. By taking these dynamics into consideration, one way to probe the behaviour of microfinance clients is to survey the practical experience of both clients and credit officers. This is because the former enforces top-down rules set by the MFI whilst, at the same time, the latter must self-organise coping strategies to ensure group-level compliance with the top-down credit rules. These bottom-up conventions are the focus of the fieldwork data collection and analysis, which then –once thoroughly understood and discussed with the available stakeholders– informed the development of the ABM[2].

Initially two cross-sectional surveys were designed and administered at the MFI with a time frame of four weeks, with a two month interval between them. One to credit officers and another to credit clients. The first administered survey was designed to to elicit data about the experience of credit offers with regards to their own administrative tasks. The second administered survey was designed to elicit what were, at that time, the social conventions and structural composition of groups with regards to their debt. Once data from both surveys have been analysed, other two follow-up surveys, intended to better understand previous responses, were designed and applied only to credit officers (due to time and budget constraints). Once this process has been completed, the group and individual financial data has been analysed for that period.

[2] See further discussion in Sections 4.3.2: "Implementing the EDTM into the ABM simulation" (page 95) and 5.3.2: "The Evidence-Driven Simulation Model (EDSM)" (page 132).

An illustration of the order and relationship between surveys is provided below.

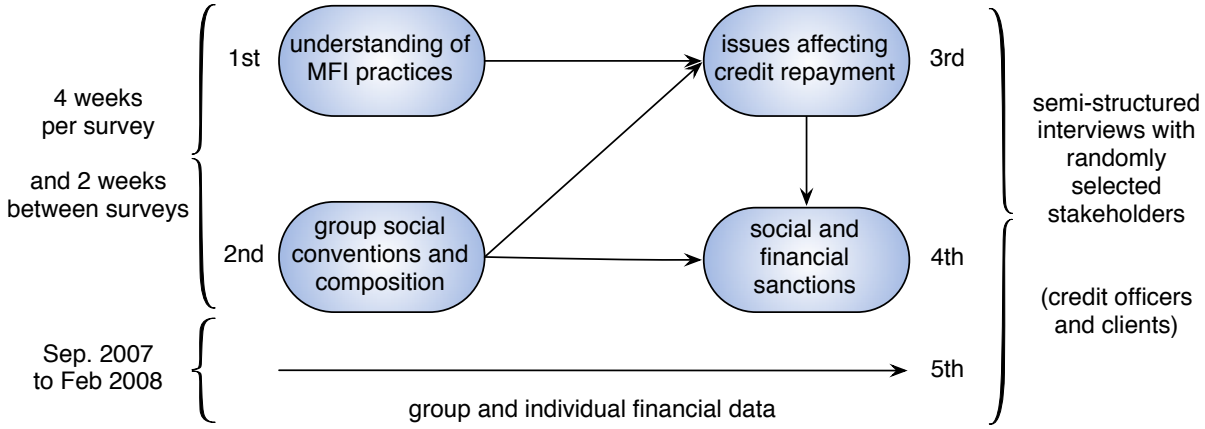


Figure 4.11: Order of the complete data collection and analysis processes

The socio-economic analysis comprised of surveying 600 microfinance clients of mixed Mayan ancestry, spread over the localities within approximately 180 km radius from the MFI headquarters (as depicted in Figure 4.10: "Raster KML plot of the 21 client locations surveyed during fieldwork", on page 77). The MFI groups ranged in size from three to seven clients, and in total 261 groups were analysed together with respective 2444 micro-loans spanning across the data collection period of the designed fieldwork.

Thus in total four surveys[3] were administered at different points in time and each collected new information, making the design cross-sectional. Most of them (3) targeted 35 credit officers and have been filled in via Web browsers accessible to employees at the MFI headquarters. LimeSurvey.org was used in a Debian.org server running Apache.org with PHP.net and MySQL.org in Manchester, England. The survey administered to the credit clients was filled in on paper, during one month as depicted in the figure above.All data has been transcribed into a database to facilitate the anonymised analysis and the paper surveys remained in an academic storage located in Chiapas, Mexico. Simple semi-structured interviews[4] with randomly selected credit officers, clients and MFI directors were also administered, between and after, September 2007 and February 2008. These consisted of randomly selecting a fieldwork finding and asking whether they would endorse it.

[3] All questionnaires are in Section 7.1 ("Appendix I: Fieldwork Surveys", page 176).
[4] I.e. a flexible model for carrying out interviews, allowing new questions to be brought up.

As different information was being collected at each step, this contrasts with those of longitudinal research design. That is because, in this research project, the same type of data is not being collected at different periods of time. Instead a cross-sectional approach was used, aiming at the collection of different data at different points in time. Therefore the approach in this thesis does not lend itself to analyse trends or trajectories regarding the social conventions adopted by the credit clients, as a longitudinal approach would. A longitudinal research design would have had an emphasis on consistency of measurements over time, as it is intended to avoid changes in how a concept is measured in practice. One would have been interested in telling apart changes that are indeed genuine about the phenomenon, and not a byproduct of measuring different aspects at different points in time. Thus the research design in this thesis contrasts with the typical longitudinal designs described in [Menard, 2001, 2007] *by not being a*:

- Total population design. Despite the three surveys administered to every credit officer, taking into consideration that some may have joined and others left from one period to the other: each survey collected entirely different types of data.

- Repeated cross-sectional design. This would have been an ideal approach to track changes in values and relationships amongst variables, using the same survey administered to the credit clients. Yet this was unfeasible due to cost and time.

- Panel design. Same subjects did not guide each data collection period; neither credit clients nor officers. This could have had been the case if the research approached retrospective cases to be understood in terms of intra-individual changes (e.g. behavioural or cognitive) which all the surveyed subjects participated.

The collected data does not differentiate which time-dependent processes influenced each variable, thus precluding the account of differences between potential explanations [Borgatta, 1991, Gilbert, 2008]. Moreover, it has only been possible to visit the MFI once, due to time and budget constraints. The carried out iterative research design allowed thus to elicit the relevant information that was unknown. And these findings became straightforward useful insights to inspire a future, longitudinal research project.

As depicted in Figure 4.11: "Order of the complete data collection and analysis processes" (page 79), the first survey contained 14 questions to credit officers; two weeks later six questions followed-up in another survey and then finally –additionally two weeks later– eight more in the final survey. The survey administered to micro credit clients consisted of five questions and was administered with the help of the MFI credit officers. The criterion to select clients was discussed with the MFI director beforehand and consisted of each credit officer choosing a maximum of three clients per day in a different credit centre that each of them had a scheduled visit. Further information in this regard can be read with aid of Table 4.2: "How credit officers chose the 600 surveyed clients [Lucas et al., 2008]" (page 82).

Each questionnaire used to survey clients has been designed to elicit information that would contribute to address the research problem and research questions introduced in Chapter 1, Section 1.3 (page 16). Merged data from their five financial databases, which were distributed throughout the MFI operation centres, were also analysed. These tracked group-level quota repayments, interest rates, gains and losses. Results elucidated the client's understanding of ethical and moral principles that contribute to enforce success of their social collateral. Moreover, it has also been possible to uncover some crucial aspects about repayment and defaulting, along with their understanding of social collateral via trust relationships. These are discussed in the next chapter.

The criteria applied by credit officers to select clients is summarised below in Table 4.2. In this chapter, table with items written in *italic font* represent answers that have *not* been considered similar by the thesis author, so these have not been aggregated with other items. Gaining insights on both how MFI employees and clients tend to deal with debts and defaulters is essential to analyse what is a social convention in terms of acceptable behaviour within groups. This is particularly noticeable in this MFI case study, as there are necessary interactions between group conventions and institutional rules.

In other words, these are the top-down rules that managed by the MFI and the bottom-up conventions adopted at the group-level only. Thus apart from the institutional rules, it has also been observed a set of group-level behaviours adopted by the microfinance clients to assess and deal with defaulters in their groups. These operate independently from the MFI framework as, despite influencing when and how quotas are repaid, the group criteria is entirely dealt with and developed within groups.

Percentage	**Criterion regarding clients**
25%	*best meeting punctuality*
20%	*best credit vs. debt history*
15%	best repayment punctuality
10% each	most responsible, best known
5% each	most defaults covered, entrepreneurial, accessible

Table 4.2: How credit officers chose the 600 surveyed clients [Lucas et al., 2008]

Furthermore, the MFI kept five financial databases and these have been analysed. That included tracking of individual performances and socio-economics, with groups classified either as being rural or urban. Records included information of the: individual instalments, active businesses, scholarly levels, group credit, quota repayment statuses and loan validity. Whilst the designed surveys focused on collecting data regarding the social conventions for dealing with debt, financial data was used to summarise the MFI perspective as to how credit had been managed. Area-specific surveys on roads and population were available as IRIS maps[5] and KML. Whilst this data was not used in this research, the MFI used this system to delineate the profile of the surveyed clients.

There is a variety of research methods that one could deploy in the domain of microfinance, so it is worthwhile considering their overall differences. Some of these are discussed next.

[5] Geographical system created by the Mexican National Institute of Statistics & Geography.

The figure below illustrates the spectrum of research approaches in this area, in terms of how likely it would result in either contributing to strengthen an association[6] or potential causality. Therefore the further right in the figure, the higher the chances are of one correctly claiming impact due to a designed intervention –and not by confounding factors.

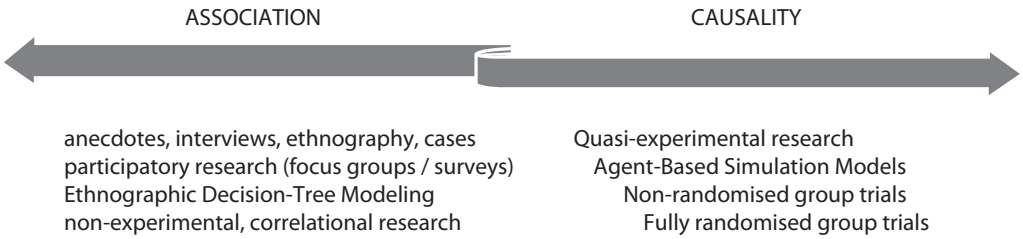


Figure 4.12: Towards association or causality, based on [Johnson, 2009, Gash, 2012] [a]

[a] Research based on mixed-methods cross this gap by using both qualitative and quantitative data [Creswell and Clark, 2010, Geller et al., 2010, Ledgerwood et al., 2013, Pedhazur and Schmelkin, 1991].

Bearing in mind that most (quantitative) economic and (qualitative) social data is non-experimental[7], variables are not manipulated but measured directly from a population. Association analyses made only with this type of data present confounding likelihood and thus cannot be used to strengthen causation [Dunn, 2000, Keuzenkamp, 2006]. On the other hand, non-experimental data is excellent to characterise the phenomenon of interest and for this reason is a helpful source of information to design experiments. A behavioural economic setup, for example, can be used to analyse results of quasi-experiments[8] carried out with real subjects, who themselves contain non-experimental data [Guala and Salanti, 2001]. Another example of a quasi-experimental design is an ABM, where endogenous variables of interest can be computationally tested without exogenous interferences. This allows the design of experiments using a factorial design, with simulations aimed at testing would-be scenarios configured with parameters where the assignation of control and experimental groups would otherwise not be fully known.

[6] I.e. a simple correlation of variables, which would have no bearing whatsoever on causation.
[7] I.e. data originating from a process that the researcher cannot fully control or experiment.
[8] I.e. a fully controlled environment where non-randomly selected subjects are grouped, with at least one independent variable being manipulated and a dependent being variable measured.

Randomised Control Trials (henceforth RCTs) have been widely regarded as the most rigorous research method because they: (a) avoid selection biases by ensuring control and treatment groups are essentially identical on average, (b) can test multiple interventions at once and (c) are more reliable, less costly in the long-term as it effectively provides a public good to other research projects[9] [Segone, 2008, Karlan et al., 2009, Johnson, 2009]. Yet various practical limitations, such as budget and time[10], can impose severe difficulties to carry out an RCT research design. When an RCT is either unfeasible or inappropriate, it is worth considering the quasi-experiment as a good research design alternative. That is because a quasi-experiment allows: (a) exploratory research[11], (b) hypothesis-testing[12] and (c) provide similar results to RCTs[13]. On the next page, Table 4.13 contains a "Summary of experimental methods used to study microfinance, adapted from [Johnson, 2009]".

Quasi-experimental research either compares before and after conditions within the same group or a treatment and a control in different groups. Both approaches can be analysed using surveys or experimental data[14]. Simulation runs of an ABM can thus serve for quasi-experimental testing as, like a RCT, one can set out to analyse the effect of different factors by controlling what changes. In quasi-experiments one can claim the elimination of exogenous interferences as the experimental conditions are fully controlled, including the selection bias itself [Guala, 2005, Lehtinen and Kuorikoski, 2007, Mäki, 2005]. In other words, a quasi-experiment is an approximation to the true RCT experiment given the practical conditions that one can actually experiment with. Therefore, due to the flexibility of quasi-experimental designs, one can explore and test hypotheses with less resources and identify the most likely impact measures that could then be proposed for a full RCT design, e.g. targeted at informing policy-making.

[9] I.e. one can determine which impact or result is directly attributable to the intervention.
[10] Sometimes also ethical, as a potential result of an experiment may not be acceptable.
[11] Also referred to as formulative research, as it leads mainly to new insights and hypotheses.
[12] With the caveat that this is done using simulation, not empirical or experimental, data.
[13] I.e. an identical setup to quasi-experiments but where the participants of both treatment and control have the same chance, in average, to be selected [Pedhazur and Schmelkin, 1991].
[14] For instance, as a result of assigning different loan contracts to the same MFI clientele or the results of an experiment setup with a software for experimental economics such as zTree.

Method	Application	Advantages	Disadvantages	Usefulness
Randomized control trials (RCTs) comparing treatment and control groups.	Use of structured surveys to measure variables and changes are attributable to the steps from a suggested chain of results when samples are sufficiently large.	Regarded as the most rigorous statistical method; avoids "selection bias" because the treatment and control groups are identical on average.	Difficult to design and administer if the treatment group is self-selecting. In such case, a randomly assignment incentive to participate may be assigned, in order to mitigate the possible selection bias. Another disadvantage is that the research questions cannot be adapted mid-study.	Useful for measuring the effects of specific innovations where randomization is possible and for measuring the impact variables of interest (for example, specific products or services such as savings accounts, or whether insurance has an impact at all).
Quasi-experimental can compare either results from different configuration sets or a treatment and control.	Use of structured surveys to measure changes attributable to a step in the results chain; could be useful for pilot projects.	It can provide a better approximation to the reality as there is no exact control as in a RCT. It is comparatively easier to implement and results are similar.	Easier to implement than RCTs yet results can be similar. Control group is not fully counterfactual when comparing with the treatment group. Thus it may become irrelevant if these are too similar. Quasi-experiments have similar costs of a RCT, yet these can be reduced by using simulations.	Similar to RCTs, as one can investigate differences between configurations and specific interventions. For these reasons a quasi-experimental method is the likely best choice when a full RCT is not feasible due to either operational, time or budget limitations.
Participatory approaches (for example, focus groups and EDTM).	Best choice when one is unsure which factors should be taken into account to understand behaviour. Methods are mainly inductive.	These methods help to suggest attributions or uncover unexpected individual or group behaviour and preferences.	Due to induction, these methods can contain degrees of subjectivity and so may be subject to biases. For this reason researchers are generally encouraged to disclose upfront these potential influences.	Useful to elicit information, particularly regarding behaviour and preferences at the individual or group level. Results can be informative to design RCTs and quasi-experimental research.
Qualitative information from key informats (e.g expert interviews, ethnography, narratives, case studies that depend on quantitative data)	When the key change is driven by one person (e.g. local policies) or an organisation that can be clearly defined limits of operation.	Low cost and can elicit the "why" that drives the change and it can provide good suggestions for attributions.	Same issues as mentioned in the previous line of this table. This is also due to the inductive approach. Thus it may not represent well the diversity of the niche, as these time-consuming methods are designed to be case specific.	It can provide rich information to understand why change has happened and the rationale behind each action. Therefore it is useful to understand how the study in question has developed and may possibly suggest patterns in it.

Figure 4.13: Summary of experimental methods used to study microfinance, adapted from [Johnson, 2009]

4.3 Evidence-Driven Approach to Modelling (EDAM)

An alternative way to explore the open issues regarding behaviour within microfinance groups, as introduced in Section 2.2: "The Role of Microfinance in Public Goods" (page 28), is to build an ABM. That is because the variations of individual social preferences and group circumstances can be systematically tested without exogenous interferences. For instance, one can test the provision of a public good, in the form of a microfinance group, using configurations that may shed light onto the impact within the group dynamics based on the interaction of different individual behaviours.

An in-depth example of this approach, which uses experimental data for the input of an ABM, is discussed in [Lucas et al., 2014]. The control variable in the aforementioned paper has its origins in public good experiments, which robustly demonstrated that individuals can sacrifice their own interest in order to help others [Camerer and Fehr, 2001, Charness and Rabin, 2002, Fehr and Fischbacher, 2002, Henrich and et al., 2001]. A set of individual social preferences has then been experimentally identified [Ahn et al., 2003, Burlando and Guala, 2005] and the combination of these has been implemented in an ABM. That is in addition to the traditional *homo economics* social preference of individuals maximising their own profit. This is an example of how a phenomenon of interest, which is demanding (both time- and cost-wise) to test with a RCT, can be further understood by analysing test results obtained from a simulation model (i.e. a quasi-experiment).

Both the previous section and chapter have highlighted some critical methodological issues regarding the development of social simulation that ought to provide useful results beyond theory to stakeholders. In order for this research exercise to be as useful as possible to the MFI stakeholders, a decision has been taken to involve them from the very beginning of the research process.

There is no implication that social simulation modellers should approach hypotheses strictly as problem-solvers or service-providers, but academics should be mindful of the aforementioned *status quo*. Stakeholders are rarely interested in how the social phenomenon is modelled, but would rather like to know what are the pragmatic contributions –or consequences– from models. This is understandable, particularly if considering that currently social research findings taken into practical account tend to derive mostly from fieldwork or the modelling process itself –not from an ABM. The proposed development lifecycle aims at mitigating some of the persisting modelling issues by:

- (a) emphasising the importance of data collection and analysis as a requirement to significantly enhance one's ability to build social models and interpret results;

- (b) focusing modellers on being attentive to the need to strive for useful new knowledge, both for academics and stakeholders, regarding a social phenomenon.

As introduced in the previous section, simulation models of social behaviour are currently only useful to stakeholders as a test platform of hypothetical scenarios. Social simulations generate synthetic data about real social systems and thus require domain experts to properly evaluate the usefulness of the results. Academic analyses tend to focus on technical aspects regarding design, representation and simulation dynamics. These involve, for instance, studying the model sensitivity to certain parameters, overall maintenance and replications [Edmonds and Hales, 2003, Galán and Izquierdo, 2005].

To clarify the involved processes and their relationship in the proposed modelling approach, refer to the illustration below whilst reading the explanation that follows. The diagram has evolved during the development of this thesis and depicts how modelling has been conducted, which enabled the building of the ABM[15] with guidance provided by the data collected about processes within groups[16], following the research design[17].

[15] See Section 5.3.2: "The Evidence-Driven Simulation Model (EDSM)" (page 132).
[16] Fig. 4.11: "Order of the complete data collection and analysis processes" (page 79).
[17] See Figure 4.17: "The adapted EDTM development cycle" (page 93).

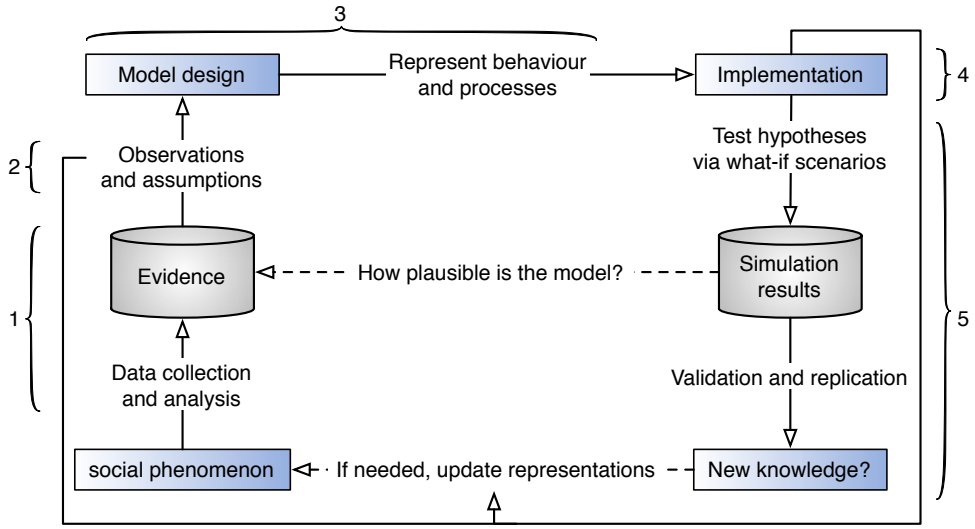


Figure 4.14: Evidence-Driven Approach to Modelling (EDAM) [Lucas, 2011]

The lifecycle for developing an ABM social simulation is described in these steps:

1. The target system represents the social phenomenon itself, from which evidence should be collected and analysed. This might require, for instance: administration of questionnaires, survey socio-economic circumstances and/or setup of an automated strategy for collecting behavioural data[18] from the stakeholders.

2. With analysed evidence, modellers proceed to discuss the plausibility of observations and assumptions with stakeholders. Here there is a potential loop as both researchers and domain experts must reach a common understanding of what has been analysed and whether hypotheses are based on realistic assumptions.

3. To design the model based on scrutinised evidence, which at this stage has been verified by stakeholders[19], it is a good idea to differentiate what is essential to be in the model from what is contextual data about the social phenomenon. The latter comprises much more than the former, thus caution must be observed.

[18] Larger datasets have greater chances of providing richer analyses leading to useful findings.
[19] I.e., the data can serve both to verify and justify how the social simulation has been built.

4. Deciding how to implement agent behaviour and processes is entirely up to the modellers, as no evidence favours any particular computational paradigm. Most approaches nowadays use object-orientation[20] due to the relative ease of representing behavioural features in simplified, self-contained autonomous threads.

5. Having a feasible model built based on the evidence, modellers can then proceed to explore and test hypotheses using scenarios that resemble social phenomena observations. Results are then compared to evidence and, to strengthen validation and development of knowledge, findings should ideally be discussed with domain experts.

In case simulations consistently diverge from what has been observed in reality, it is likely that something in the model has either been misrepresented, implemented incorrectly or that parameters were set unrealistically. It is generally accepted, both by academics and practitioners, that social simulation models should at least generate results that are plausible in light of the existing (qualitative and/or quantitative) evidence [Moss and Edmonds, 2005]. It is recommended that modellers test the technicalities of their simulation models before reaching the fifth step, described above. A more complete validation of obtained results in an ABM is only possible once the model has been deemed plausible, both by academics and stakeholders. From this milestone onwards modellers can try to *mediate the development of new knowledge* about the phenomena –not the model itself – via the interpretation of obtained simulation results.

The difficulty in making social simulation models useful beyond theory, as highlighted in Section 3.2.2: "Challenges in Simulating Social Phenomena with ABM" (page 61), is partially influenced by the fact that many –if not all– non-virtual social phenomena are subject to continuous contextual change. Understanding and implementing such conditions is not a trivial task[21].

[20] See discussion in Section 4.3.2: "Implementing the EDTM into the ABM simulation" (95).
[21] Note that if social interaction only occurs in online systems, such as multi-player games or social networking websites, users' actions can be fully controlled and monitored in real time.

As discussed, fieldwork analyses has currently far greater chances of producing useful findings, as it is feasible to provide up-to-date reports about specific aspects of the social phenomenon that might still be observable. Conversely simulation models often operate in much longer time scales, and this sometimes imposes difficulties to address simulation issues carried from modelling to implementation.

The fifth step on the previous page contains an important task, recommendable to be carried out, both to well established and newly developed models: replication. An ABM should ideally be replicated by modellers and compared as to how robust the original results actually are. In this process one may find issues in terms of how well specified assumptions have been done, which will allow or not a correct replication [Edmonds and Hales, 2003, Lucas and Payne, 2014].

It is worthy noticing that, if modelling one social phenomenon demands enough to the point of challenging the generation of useful results beyond theory, one should bear in mind the difficulties of nesting simulation models. This is not a difficult technical task, but it adds a considerable level of complexity to evaluate results obtained in such mixed models. ALife, artificial societies and other virtual simulation systems have long explored this by integrating, or nesting –in one virtual world– parallel and concurrent models. An ALife biochemical model may, for example, depend on the results of another model that simulates environmental conditions. This thesis is not focused on such cases, but that is a good example of when validation is not relevant as all in it is completely artificial anyway. That is not the case in social simulation, as the point is to gain insights about real social phenomena via analysing simulations –and not just the computer dynamics of a virtual reality. Thus it has been argued throughout this section that researchers working this social simulation must address data validation and verification from the very beginning of the modelling process.

4.3.1 Developing an Ethnographic Decision Tree Model (EDTM)

The fieldwork has been designed to elicit what the microfinance clients do when someone defaults and how credit officers understand their role in this process. That is important as the whole group has to comply with the MFI rules of collective responsibility, yet the institution did not know how this was being achieved at the group level and this was the focus of this research. One way to model this bottom-up organisation is by developing an Ethnographic Decision Tree Model (henceforth EDTM). Next, the EDTM methodology is introduced and discussed in terms of the adaptations made.

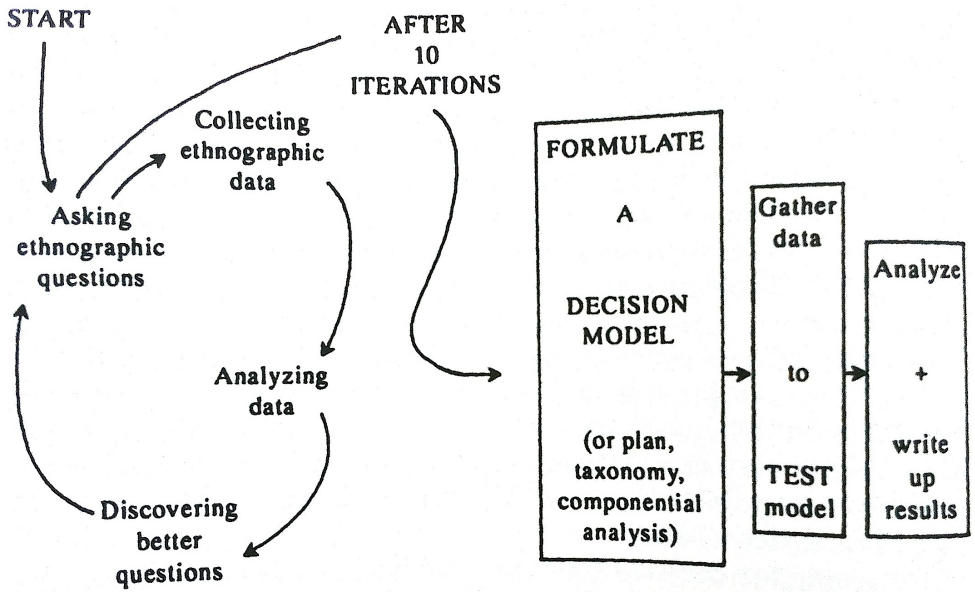


Figure 4.15: The original EDTM development cycle [Gladwin, 1989]

As it can be observed in the figure above, the original EDTM combines the ethnographic research cycle with a linear plan for hypothesis testing. EDTM is a systematic methodology for building a model of decisions taken by a specific cohort, where the process is driven by the data collected from the surveyed subjects themselves, rather than the researcher hypothesis [Gladwin, 1989]. An EDTM requires thus an approach to development that begins with the researcher selecting the decision-making context. The original proposal of the EDTM suggests the setup of an ethnographic database, containing both quantitative and qualitative information, so that this becomes the reference material for consultation throughout the process of model development.

In the approach put forward by [Gladwin, 1989], each question in a semi-structured interview corresponds to a new level in the hierarchical tree, whilst each new answer corresponds to either a new ramification or a decision. The result, as illustrated below, is a cladogram-like structure, with branches specialising according to the questions.

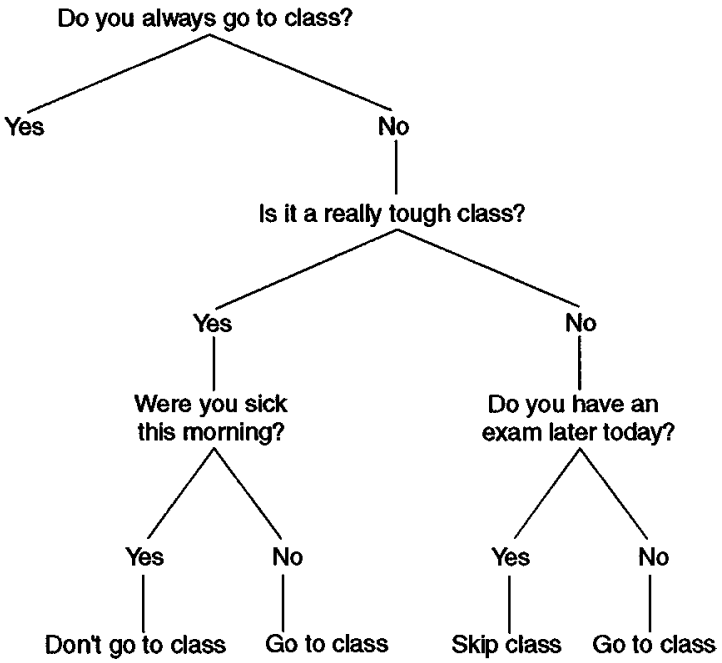


Figure 4.16: An example of an EDTM: student behaviour [Bernard, 2005]

There is no established methodology for implementing an EDTM into an ABM, thus the developed ABM[22] has been built based on the evidence collected with the aim to shed light on how the clients in Chiapas deal with defaulters in their groups. It would have been useful to have detailed information about events in the microfinance groups, such as how much each person contributed to cover a specific default. As discussed further on page 131, this data has not been collected by the MFI. To take such data into consideration, it would have been necessary to monitor events linked to quotas due after having started the data collection and apply the same survey questions to them in different points over time. This would require a longitudinal design, collecting the same data over different periods of time, but funding covered only a cross-sectional design. This design assumes irrelevance of processes and time regarding the collected data; thus it was unnecessary to account for dropout rates [Gilbert, 2008].

[22] Described in Section 5.3.2: "The Evidence-Driven Simulation Model (EDSM)" (page 132).

To apply the EDTM methodology in this research, due to not being physically able to access the decision-makers and other stakeholders located in another continent, it has become clear that some adaptations would be necessary. The EDTM adaptation allows the research to begin with surveys, which are –at a later stage– complemented with an ethnographic approach based on *in situ* observations and interviews. In this research project, this took place during one month at group meetings where events were dealt with. This means that the first phase has been done with a sequence of surveys, with the intention to increasingly raise better questions and viewpoints about the decision-making. These adaptations are discussed based on the illustration below.

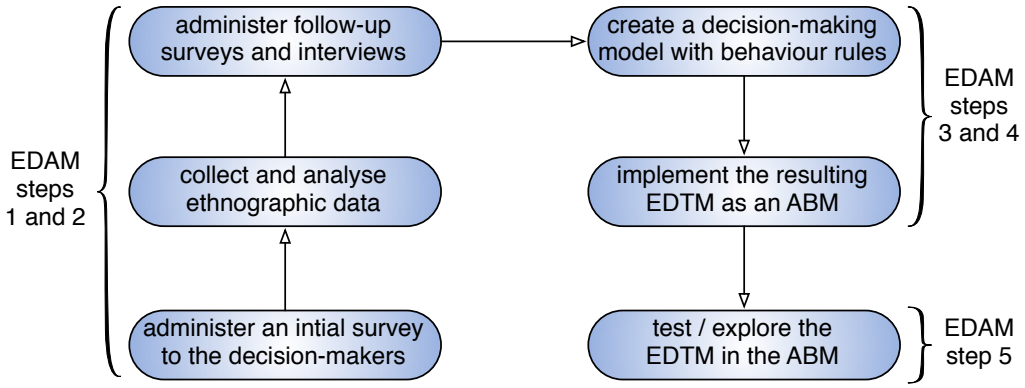


Figure 4.17: The adapted EDTM development cycle

Bearing in mind the aforementioned adaptations, the development of an EDTM required then consideration of the following aspects: framing effects (i.e. how the presentation of the decision-making process could influence the modelling itself), the criteria for choosing subjects and data collection (i.e. the administration of interviews and/or surveys, described in the previous section) and testing of the model as suggested before. These are important because the model assumes the creation of a tree-like, hierarchical structure to represent decision-making that is culturally-tuned by surveying a specific group of individuals [Gladwin, 1989, Beck, 2000]. That is the reason for arguing that it can be systematically tested via an ABM, where multiple agents are equipped with the same EDTM. The evidence database, originally suggested for the development of an EDTM, can also be used to facilitate the development of the related ABM.

A rather arbitrary suggestion from the original proposal is that an EDTM is successful if it can predict between 85% and 90% of the tested individual's choices. This may have been inspired by the concept of statistical confidence intervals, yet it remains unconfirmed if that is the case and whether the related literature would be applicable. Given the likelihood of EDTMs being based on relatively small samples, there are risks of statistical errors in testing hypotheses using the aforementioned framework as normality tests would –most likely– not detect non-normality in a small dataset [Maindonald and Braun, 2010]. This is pertinent as the EDTM has been developed, as originally introduced by [Gladwin, 1989], and then embedded in the ABM as the agent's model of decision-making. The EDTM approach facilitates the qualitative validation at the micro-level and contributes to cross-validate results of an ABM at the macro-level. This is then a variation of the cross-validation approach [Moss and Edmonds, 2005]. The EDTM is a qualitative approach to research with the goal to model how people make real-world decisions and to identify the specific criteria used by the individuals in a group [Beck, 2000]. EDTM is thus an induction-based approach that enable one to uncover unknown behavioural relationships and processes regarding actual decision-making. These findings can then lead to the formation of hypotheses that provide direction for further research involving either smaller ethnographic studies with smaller samples or quantitative studies with larger samples [Wilson and Chaddha, 2009]. This type of rich contextual information is helpful to guide the modelling of agent's behaviour in an ABM. Similar practice has been established through participatory modelling [Squazzoni, 2012], which is also a qualitative-driven approach that enables unveiling details at the micro level. Results obtained from an ABM can then be interpreted at the aggregated, collective (i.e. macro) and disaggregated, individual (i.e. micro) level.

Thus an extra contribution in this thesis is the demonstration that the result of building an ETDM[23] can be integrated in the building of an ABM. This example could also have been built in other rule-based computerised simulations, including: forward chaining (e.g. using the Java Expert System Shell, henceforth JESS), backward chaining (e.g. using Programming in Logic, henceforth Prolog)[24], or as several if-thens in the ABM.

[23] That resulted in Figure 5.23: "The proposed EDTM of decision-making within MFI groups" (page 128), discussed in Section 5.2: "Fieldwork Findings: Microfinance Clients".

[24] See Section 4.3.2: "Implementing the EDTM into the ABM simulation".

4.3.2 Implementing the EDTM into the ABM simulation

Unless the purpose of an agent-based model is purely theoretical, e.g. strictly regarded as thought experiment or demonstration, it is most likely that the modeller will have to deal with qualitative data to some extent. Agent-based developers are still generally struggling with fundamental aspects as to how should quantitative and qualitative data be used to inform model building and how experimental data, obtained from simulation experiments, ought to be appropriately analysed [Lucas, 2014]. Further evidence to this is that 2013 has been the first time the European Social Simulation Association (henceforth ESSA) has set up the Special Interest Group on this topic and hosted the dedicated conference track entitled "Using qualitative data to inform behavioral rules".

As introduced at the beginning of this chapter, there is a variety of research methods and types of data (quantitative and qualitative) the modeller can use in an ABM. Social simulation development platforms[25] are useful for building models that allow accurate demonstration and testing of hypothetical scenarios. Yet, methodological difficulties, such as those discussed in Section 3.2.2: "Challenges in Simulating Social Phenomena with ABM" (page 61), persist in preventing the provision of useful results beyond theory through the development of ABM. And one of these difficulties to represent qualitative information is the influence of the programming approach itself.

Fully procedural and object-oriented models tend to lead the modeller to represent data (qualitative and quantitative) as numerical properties and thresholds, which are then controlled by a sequential (i.e. linear) process. These can be useful to reinforce intra- and inter-agent positive or negative feedback loops, programmed to update and log aspects of the monitored numerical properties. The update frequency may depend on how long a simulation may run and whether thresholds are static (i.e. fixed) or dynamic (i.e. changeable) over time.

[25] E.g.: SWARM, NetLogo, Repast, CORMAS, Ascape, SeSAm, SDML, MASON and M4A.

As ABM simulation results are quantitative in nature, one can analyse possible correlations between parameter configurations and results, in an attempt to shed new light on understanding model path-dependency (or lock-in) properties either at the micro (individual) and macro (collective) levels. Running a sensitivity analysis[26] can help understand a model implementation regarding the use of different parameter values[27].

All ABMs are structurally similar in the sense of having both processes and data being updated at run time; even those models implemented declaratively using backward or forward chaining data processing. In the latter case, qualitative data can be represented as a rule database and is then manipulated according to a symbolic order given by resolution strategies. These involve logical constraint satisfactions, such as the Selective Linear Definite (SLD, and its extension SLDNF to deal with negation as failure) in Prolog [Roy and Haridi, 2004], or the pattern matching Rete algorithm available in production rule systems such as JESS [Doorenbos, 2001].

In these declarative examples, a model will still have some procedural feedback loops required to encapsulate these algorithms. It is crucial to check the representation consistency and ensure that implementations are coherent when confronted with evidence, otherwise the gathered data would have served of limited –if any– guidance. Nevertheless one could argue that declarative modelling, due to its different coding approach, can have the following advantages over fully procedural or object-oriented approaches:

- (a) knowledge is represented in a syntactical form that is easier to communicate with stakeholders, as behaviour and facts are written as logical structures;

- (b) fact databases and inference rules linked to individual behaviour are updated, by the modeller or model, without modification of procedural control structures.

[26] E.g. with the Model Exploration Module tool developed by Aitia.ai, henceforth MEME.
[27] Despite such task being time-consuming as an ABM may not be analytically tractable.

These advantages, particularly the second one, are useful for maintenance purposes, as not much effort would be required to update existing (qualitative or quantitative) evidence embedded in an ABM social simulation. Procedural or object-oriented models, on the other hand, usually require significant changes in the simulation source-code to reflect new evidence –specially new decision-making processes or rules. Yet it is unclear, how a declarative approach could contribute to helping with making agent-based social simulation models useful beyond theory, and thus if the extra technical effort involved in integrating these with an object-oriented simulation framework[28] bring any concrete advantage in this regard.

Although one must notice that different computational paradigms present their own technical limitations, or standards, in terms of representing behaviour and processes. Another topic that has only recently begun to be analysed in greater detail is the technical aspects of parallel and distributed model execution. To date the two most popular agent-based simulation toolkits, viz.: NetLogo and Repast, can take advantage of parallelism if modellers make use of specific Java libraries. Further to this, probably the only platform specifically designed for high-performance, taking advantage of execution on Graphic Processing Units or supercomputers, is the Flexible Large-scale Agent Modelling Environment framework (hence FLAME) [Richmond et al., 2010a].

It is worthwhile to point out that ABM modellers often implement algorithms that deal with numerous objects (agents) and data structures that require little processing per computation cycle. This feature lend itself to having rather little scalability potential [Foster, 1995] than those models where agents require more computing cycles and storage resources to execute the tasks that have been defined in a simulation time tick. The latter statement holds, except when frequent communication is needed between agents at runtime. Distribution, on the other hand, is usually more suitable when the agents' behaviours do not need to frequently exchange numerous messages over high-latency computer networks.

[28] Section 4.14: "Evidence-Driven Approach to Modelling (EDAM) [Lucas, 2011]" (page 88).

Design and implementation of these features are usually dealt on a case-by-case basis, so that each simulation model may be implemented with specific technical issues taken into account. The Application Programming Interfaces (henceforth APIs) of all aforementioned popular social simulation platforms provide basic and general structures that modellers adapt to their specific needs. For example the @ScheduledMethod Java annotation in Repast Symphony[29] (v. 1.1.0) iterates over all active objects in an ABM simulation, executing methods associated with each type as threads of a single program.

Time-division and concurrent multiplexing[30] are not equivalent to parallel data or task execution in architectures with multi-core processors and distributed memory. Aforementioned APIs (apart from FLAME) do not oversee concurrent or parallel runs, so modellers must tackle issues such as those of starving threads (i.e. not being able to access the processor). Effective design and execution of a parallel ABM is generally rather incipient if compared to the long-established running of simulations using context-switching[31] [Lysenko and D'Souza, 2008, Cicirelli et al., 2009, Richmond et al., 2010b].

Albeit relevant for considering the development of an ABM, until the present date, no published comparison is available about replications done in procedural, object-oriented, parallel and declarative paradigms. [Edmonds and Hales, 2003] did, but only using a declarative and an imperative language. It is unlikely that there would be any significant difference in representing quantitative information in different approaches. Yet the representation of qualitative data depends directly on how a paradigm allows such implementation. Hence because of this particularity, it is likely that there would be some important difference between the replicated versions of an ABM using the aforementioned paradigms. This remains an open research problem. In this project, the implementation of the EDTM as an ABM has been fully object-oriented.

[29] The project's JavaDoc is available online at http://repast.sourceforge.net/docs/api.zip
[30] A multi-threading approach popularly used as pseudo-parallelism in single core processors.
[31] I.e., scheduled storing and restoring states to enable resuming execution of multiple tasks.

Summary and Conclusions of Chapter 4: Research Design and Development

This chapter discussed how the research design has been conceived, organised and carried out in order to develop this research project. The discussion includes details on the approach to data collection and analysis, with particular emphasis on how these impacted the development of the agent-based social simulation. For this, an evidence-driven approach has been introduced, which takes into account issues of integration of both quantitative and qualitative date into a model.

The MFI context during the data collection process has been detailed, including the criteria adopted for choosing which credit clients that have been surveyed. Different approaches to experimentally research microfinance are discussed and then an adaptation of the Ethnographic Decision Tree Model is presented. Data from the MFI stakeholders has been collected through a combination of surveying stakeholders and *in situ* observation.

Thus the chosen methods for carrying out this research project include the following.

- a) an adaptation of the Ethnographic Decision Tree approach, allowing iterative surveys that are then complemented with semi-structured interviews;

- and b) the implementation of an agent-based model based on fieldwork findings, allowing the experimentation with different scenarios of microfinance groups.

Chapter 5

Research Findings

This chapter contains a discussion about the research findings grouped in sections of the TOC below. The chapter highlights the outcome of carrying out the research design previously discussed and how the data analysis has been done. This includes a detailed discussion on how the EDTM has been developed and used for guiding the implementation of behaviour in the ABM. In accordance with the discussion in Section 4.3: "Evidence-Driven Approach to Modelling (EDAM)" (page 88) and Section 4.3.1: "Developing an Ethnographic Decision Tree Model (EDTM)" (page 93), all findings have been discussed and deemed plausible by the stakeholders. The contributions to knowledge, based on the sections below, are discussed in the next chapter.

Contents

5.1 Fieldwork Findings: Credit Officers

Table 5.3 below introduces the first result from the administered surveys to credit officers[1] –which are the most common reasons, perceived by them, compelling credit clients to pay quotas on time. These surveys were designed to understand how the MFI employees interpret the impact of their policies over the financed groups and how clients actually behave within groups to repay credit.

Item	Percentage	Categories
1	18%	conditions in which credit must be repaid
2	16%	examples of solidarity (e.g. covering defaults)
3	16%	mutual supervision between participants
4	15%	mutual monitoring (by the MFI and groups)
5	15%	abide to group rules (MFI and conventional ones)
6	14%	economic rentability of their businesses
7	3%	attributed to case-specific experiences
8	3%	surveyed stakeholder did not answer

Table 5.3: Perceived factors influencing timely quota repayments

The experience of credit officers suggests a close relationship between the processes surrounding the microfinance social collateral (items two to five) and economic effectiveness (items one and six). The timely concurrence and convergence of these two aspects are considered essential for the successful implementation of microfinance SE frameworks [EMES and UNDP, 2006, Borzaga et al., 2008b]. Knowing how credit clients use social collateral mechanisms is helpful to tailor microfinance services and avoid the side effects of not taking the conventional behaviour within groups into consideration at all [Armendariz and Morduch, 2005, Mas, 2009, UNITAR, 2013, Ledgerwood et al., 2013].

[1] According to Figure 4.11: "Order of the complete data collection and analysis processes" (page 79) of Section 4.2: "Design of Data Collection and Analysis", Chapter 4.

Otherwise MFIs may be at the risk of increasing interest rates unrealistically, in an attempt to offset the high administrative costs emerging from a large number of small loans and not understanding the mechanisms underpinning social collateral [Palier, 2004, Rosenberg et al., 2009, Hermes and Lensink, 2007]. These consequences would be undesirable as those may shift the MFI mission from mainly alleviating to mainly profiting from the impoverished clients to stay afloat. Further to this, as also pointed out in [Karlan, 2007], individual knowledge of someone's default circumstances within groups is crucial to assess whether eventual defaults within a group should be covered: would it be due to moral hazard[2] or genuine personal difficulties? Culture and tradition can play a significant role in shaping the conventional social behaviour used for dealing with disputes and management of defaulting [Swidler, 1995]. In this sense, detailed sociological and economical evidence can be relevant to stakeholders and academics interested in analysing microfinance policies in different places around the world. Due to the innovative nature of microfinance, one could mitigate the under-provision of public goods[3] through its social and economic embedment [Lucas et al., 2014].

Considering that the studied MFI had, during the data collection period, an overall portfolio risk of group defaulting below 1% and ongoing repayment rates over 90%, it is remarkable that no interference took place on how groups were formed or managed. Other MFI frameworks, notoriously those similar to FINCA, contrast with the researched MFI as the former framework is more selective and more rigid institutionally. That is because clients would have more frequent contact with the MFI staff, who then have to update the group members about the statuses of their loans and individually advice who may use savings to cover defaults. This may be beneficial in order to protect the more vulnerable clients from being exploited by other members, as it could arguably encourage a more egalitarian interaction within groups. However it is also known that very frequent contact between credit officers and clients (e.g. weekly) may result in MFI employees acting in less considerate ways toward group members due to the intense managerial pressure to keep high repayment rates [Harper, 2002].

[2] In this case, meaning an unwarranted default that is actually undetectable by other peers.
[3] See Section 5.4.2 "Modelling Guidance and Impact on Policy-Making", page 163).

The case study MFI in this thesis only employs credit officers to act as supporters of their SE framework. In other words, they are explicitly trained to not interfere in any way on how groups are formed and deal with their debt or defaulters. That means the credit officers' role in meetings, where credit is given and quotas are repaid, is to only facilitate the financial consequences of the clients' intended actions. The MFI thus tracks the economic performance of their financed groups and not individuals, expecting the clients themselves to deal with their debt and defaults. As the group has to evaluate the effect of their collective actions, there is a need of an in-depth understanding of which services each client is using. These include interest rates for credit, savings and potential institutional fines in case of defaulting within groups. This also means that clients must learn to manoeuvre their micro enterprises in light of what is feasible investment-wise, which requires their awareness of risk management and leadership. Despite the similarity between the Grameen Bank and FINCA microcredit frameworks, the studied MFI has adapted their own institutional rules as it follows:

- (1) micro-savings are not a mandatory prerequisite to access micro-loans;
- and (2) micro-loans may be used for other purposes than economic activities.

This flexibility implemented by the MFI provided their clients with a greater leeway to plan, by themselves, how much should be invested in their micro-enterprises or improve their living conditions. That seems to play a key role in how groups develop their own ways of sanctioning individual defaulters, as otherwise only the MFI would. Institutional screening does not guarantee cooperation amongst members, so the conditions for that amongst clients themselves must be developed and sustained to encourage successful credit groups. In order to harness social collateral[4], the institution has to strike a balance between the demand for understanding financial constraints and the interplay between top-down (institutional) and bottom-up (group) conventions[5]. Having an empirical and detailed understanding of this process is crucial, both for guiding the development of an ABM and to inform policy-makers based on simulation results.

[4] The concept has been defined and discussed in Chapter 2: "Social Enterprise" (page 17).
[5] Discussed in Section 5.4.2: "Modelling Guidance and Impact on Policy-Making" (page 163).

As most surveyed clients have had previous experience with some other form of saving or lending between themselves, credit officers provided a rather clear account of groups considered to be successful. Tables 5.3, 5.4 and 5.5 contribute to understand and represent the circumstances surrounding behavioural patterns adopted by successful groups. Some of the most relevant support aspects –such as the overall importance of collective liquidity of micro-loans– are listed below, in descending order of importance.

Item	**Percentage**	**Categories**
1	*66%*	*general mutual help*
2	20%	case-based cooperation[a]
3	6%	trust between participants[b]
4	6%	focus on common goals[c]

[a] Merged with: group comprehension (5%) and solidarity (2%).
[b] Merged with: camaraderie (2%) and sense of sharing (2%).
[c] Merged with: reciprocity (2%), union (2%) and equity (2%).

Table 5.4: Support as perceived by the microcredit officers

All top-listed items in *italic* indicate that they have *not* been merged with other qualitative concepts extracted from the data collection process following the EDTM approach[6]. By taking into consideration the explanation above, it is possible to notice that the social circumstances suggested by the listed items in Table 5.4 (particularly one and two) are in unison with listed items one, two and three in Table 5.5.

The qualitative data analysis has been done using only the following systematic approach, having each full response as the unit of analysis: qualitative categories have been created, in order of occurrence and based on the author's interpretation, as to either belonging to an existing or a new category.

[6] This includes data obtained by applying the proposal discussed in Section 4.3.1: "Developing an Ethnographic Decision Tree Model (EDTM)" (page 91) with surveys and interviews.

A sense of reciprocity amongst clients endorses, to some extent, their behaviour as not necessarily altruistic but geared towards a common good in which they themselves have individual gains. In this case study that means having a successful microcredit group.

Item	**Percentage**	**Categories**
1	*25%*	*collective avoidance of individual defaulters*
2	18%	group financial progress is steady overall[a]
3	17%	general mutual help tends to be encouraged[b]
4	8%	mutual monitoring (by the MFI and group)[c]
5	6%	encouragement of efficient problem-solving[d]
6	6%	collective and self-organised decision-making[e]
7	*4%*	*collateral is optional for collective credit liquidity*
8	4%	group training (including financial education)[f]
9	4%	frequent communication (in-group and with MFI)[g]

[a] Merged with: debts can be covered collectively (10%).
[b] Merged with: sense of comradeship, sense of belonging (6%).
[c] Merged with: pressure on defaulters (2%) and agreements (2%).
[d] Merged with: collective non-financial security (2%).
[e] Merged with: solidarity examples (e.g. covering individual defaults) (4%).
[f] Merged with: encouragement of specific example of cooperation (2%).
[g] Merged with: clear credit to clients and officers (2%).

Table 5.5: Advantages of the microfinance framework, according to credit officers

Table 5.6 below present which actions the surveyed MFI officers have witnessed in terms of how clients provide support or solidarity to their group members[7] in practice.

Item	**Percentage**	**Categories**
1	50%	support (i.e. cover defaults of) who is ill
2	10%	pay funeral homages
3	10%	moral or economical aid
4	10%	visit who missed meetings [a]
5	10%	cover someone's default
6	10%	provide general help

[a] This can be done either individually or in groups.

Table 5.6: Supportive actions witnessed in microcredit groups

[7] Apart from items 1 and 2, all others have been witnessed by the author during fieldwork.

Nearly 90% of all answers, in the last table on the previous page, contained descriptions of specific cases in which one client helped another to solve a problem. The remaining answers referred to strategies employed by clients for mutual monitoring. Thus there is a strong suggestion, grounded on the data collected directly from the stakeholders, that the social collateral[8] concept is essential to individual behaviour within groups in terms of defining what is conventionally acceptable behaviour by other group members.

A complementary information to the findings obtained in the first administered survey, is that the last follow-up survey data unveiled the fact of over 80% of credit officers have dealt with clients who used other forms of collective saving –or lending– before joining the researched MFI. This is indicative that frameworks similar to ROSCAs or ASCAs[9] have been experienced by the community of clients prior to them joining the offered MFI services –which is in line with well-known trends [Ledgerwood et al., 2013].

Furthermore, Table 5.7 present the approximate distribution of how moral and ethical principles are perceived within credit groups in which officers have worked with.

Item	Percentage	Categories
1	*22%*	*responsibility*
2	21%	honesty[a]
3	15%	solidarity[b]
4	12%	discipline[c]
5	*10%*	*hardworking attitude*
6	9%	communication[d]
7	9%	value people's needs[e]

[a] Merged with: respect (10%).
[b] Merged with the synonymous (in MFI terms): mutual help (3%).
[c] Merged with: commitment (5%) and institutional rule-abiding (2%).
[d] Merged with: trust relationships (5%) and sincerity (3%).
[e] Merged with: attentiveness (2%), cooperation (2%) and assistance (2%).

Table 5.7: Moral and ethical principles perceived within the surveyed groups

[8] I.e. the backup of collective responsibility over credit using one's own social network.
[9] For more details about this topic, please refer to Section "Social Enterprise" (page 35).

Whilst discussing fieldwork findings with stakeholders and academics, simplicity has been adopted over lengthier discourse. Simplifications were only done as long as the case study had not been distorted into a narrative that obscured the original complexity of the socio-economic phenomenon. The best way to engage stakeholders and academics in meaningful discussions about the research was to highlight the relevant findings without overshadowing the contextual information –which was often both intricate and necessary to understand the socio-economic phenomenon in question. Hence the grouping seen in Tables 5.4, 5.5, 5.7 and 5.8 considered the importance of differentiating answers by: (a) those contributing more to the overall sample representativeness; and (b) the less frequent answers, considered as being the less controversial for merging. The criteria has been entirely devised and implemented by the author of this thesis.

Table 5.8 illustrates how answers from Table 5.7: "Moral and ethical principles perceived within the surveyed groups", can influence actions between clients that have been observed by credit officers. Given the relative frequent contact of MFI credit officers with clients, it is somewhat surprising that there were not more answers linking these. Only items three and six, listed below, clearly relate trust between MFI employees and borrowers. These results reinforce the argument widely accepted that microfinance groups manage collective credit themselves [Rutherford and Arora, 2011].

Item	**Percentage**	**Categories**
1	*28%*	*paying quotas on time*
2	*12%*	*covering eventual defaults*
3	*12%*	*committing officers to groups*
4	12%	integrating clients[a]
5	12%	improving group communication[b]
6	9%	managing commitment between clients[c]
7	6%	improving time management[d]
8	6%	repaying debt in warranted adversity[e]

[a] Merged with: promoting trust amongst clients (6%).
[b] Merged with: getting better along (3%) and communicating payment dates (3%).
[c] Merged with: shared responsibility (3%) and managing officers' trust (3%).
[d] Merged with: enforcing punctuality (3%).
[e] Merged with: supporting who is ill (3%).

Table 5.8: Actions within groups supported by participants' morality and ethics

An effective MFI framework shall seek to increase the collective likelihood of the credit clients to recover from economic shocks, without completely compromising their ability to access new credit and repay quotas[10]. These are essential aspects to running a successful microfinance framework [Palier, 2004, Karlan, 2007, Rosenberg et al., 2009]. Yet interestingly, despite the MFI in this case study being less regimented than the Grameen Bank and FINCA approaches, the surveyed credit officers still perceive their framework as being overly rigid. Perhaps, as witnessed *in situ* during the ethnographic fieldwork observing behaviour in credit centres during one month, that is due to credit officers not being allowed to autonomously provide solutions to individual client needs.

In addition to the aforementioned observation regarding the adapted MFI framework, the perceived absent moral and ethical principles reported in the administered survey, can be interpreted as roughly corresponding to what opposes the categories presented in Table 5.7 (page 106) and Table 5.8 (page 107). Analogously then, one can also infer that these probably play an important role in the perceived qualitative difficulties within the researched microfinance framework. These are presented in Table 5.9 below.

Topic	**Issues described by the surveyed credit officers**
credit, timing, management	slow authorisations, impossibility to pay in advance, mandatory investments, credit only available to groups, lack of monthly repayments, inflexible repayment dates, clients want faster credit progression and initial credit is too low
communication	officers get late for their visits to credit centres, insufficient communication, misunderstandings and wrong information
meetings	mandatory presence of clients (attendance is strict), clients are unwilling to feel like students and there is not enough time for the credit officer to perform all their planned tasks
late payments	no juridical or other methods to recover losses in due time
microcredit groups	disorganisation, badly oriented groups, difficulties with distance between clients and not having groups working as one
other issues	untrustworthiness, methodological misunderstandings, lack of interest amongst clients and officers not overseeing rules

Table 5.9: Disadvantages of the framework, according to credit officers

[10] See e.g. Table 5.3: "Perceived factors influencing timely quota repayments" (page 101).

Further details on the aforementioned aspects have also been observed in the data collected in the first survey[11]. That included the provision of post-credit consultancy to the financed businesses; approximately either to some (45%) or most (45%) groups served by them. A minority of credit officers (10%) reported that they have been able to provide that service to all microcredit groups served by them.

In an apparently paradoxical result, 53% of credit officers did report that clients could miss both meetings and quotas, yet 72% of credit officers observed that there is another trend regarding individuals missing meetings but not their payments. This unexpected finding may be due to one, or perhaps a combination, of the following reasons:

- the question in the administered survey being misunderstood –yet this does not seem to be the case, given the interviews during the ethnographic fieldwork;

- the experience of officers in this regard varying substantially over time –a fact that would not allow a uniform accumulation of evidence collected via surveys;

- or indeed both possibilities occur rather frequently amongst MFI groups –which seem the most likely, given what has been observed during fieldwork.

The perceived value of having such a detailed account of these aspects lead the MFI to systematically incorporate an account of these events –by adding this data as a requirement in the development of their new information system. The impact of this finding is that credit officers will be collecting data about behaviour in the managed groups, and not only observe it during visits to the credit centres. This will allow the MFI board of directors to analyse, over time, what is happening behaviour-wise within the financed groups. This research, on the other hand, is a cross-sectional analysis.

[11] This document is available in "Appendix II: First Fieldwork Report" (page 180).

Following the discussion of findings first reported in [Lucas, 2009b], one can observe that the majority of groups have kept the same amount of credit (154) and members (148). Some (980 groups kept exactly the same people in their groups after renewing credit. Due to MFI board members reporting a steady occurrence of groups increasing credit over time, it was to some extent an unexpected finding that only a minority (67 in total[12]) of experienced groups[13] changed their instalments. This may be due to having carried a cross-sectional fieldwork, as the data analysis depend on what has been captured of the complex phenomenon, and so it does not allow a longitudinal analysis.

A longitudinal design was unfeasible due to the need for extra funding and time to track the MFI credit officers and clients over time[14]. If that had been possible, a more detailed analysis would have been done in terms of understanding the dynamics of how groups –and potentially the social conventions too– change over time. A longitudinal approach would have the potential to shed new light on how the conventional social behaviour evolves in group membership. Such an approach could allow the analysis of the degree in which this is an indirect or an intentional process –with the possibility to review the adequacy of credit instalments depending on group sizes and location.

Table 5.10, next, synthesises what credit officers consider the most relevant aspects for achieving the best results whilst working for the MFI [Lucas et al., 2008]. The financial perspective is seen through the employees' perception of what is important to do for providing the financier good bookkeeping. The operational and methodological aspects overlap with regards to the importance of managing trust amongst clients; also from clients to credit officers, in order to keep up with the implemented microfinance scheme. These last two facets are some of the most relevant for MFIs, as lacking either is a key indicative that lead traditional banking to fail servicing the very poor.

[12] Or totalling 87, if the remaining 20 first-time groups are also added to this analysis.
[13] I.e., groups with more members working with the MFI for more than one full credit cycle.
[14] As described in Section 4.1: "The MFI Context during Data Collection" (page 76).

Aspect	Answers given by the credit officers
financial	accurate information on managing debt and clients' needs in a very considerate manner.
operational	service efficacy, promotion of trust between clients and officers for dealing with losses.
methodological	trust clients to solve social and economical problems, under the microfinance umbrella.

Table 5.10: Indispensable features for the efficiency of the studied MFI

Table 5.11 below contain the suggestions, mentioned by the surveyed subjects, to improve different aspects based on their experience dealing with clients and the perspective of Table 5.9: "Disadvantages of the framework, according to credit officers" (page 108). The financial aspect (of using individual savings to serve as collateral) is conceivably inspired in schemes similar to ASCAs or ROSCAs[15]. This is particularly due to the evidence that officers know that most clients have already experienced other forms of collective saving, or lending, before joining a microcredit framework [Lucas, 2009a].

Aspect	All suggestions from surveyed officers
financial	promote voluntary savings within groups, along with recommendations for using smallest possible deposits to backup every credit.
operational	take more into account feedback from meetings both to improve focus on social issues and explain the framework to clients.
methodological	adapt some MFI rules according to groups' locations, whilst maintaining a continuous *in situ* training program (workshops) to clients.

Table 5.11: Suggestions to improve the studied MFI framework

According to data in Table 5.12: one can see that illnesses (23%), lack of profitability (14%) and poor investments (11%) are the leading causes to defaulting within financed groups [Lucas et al., 2008]. During fieldwork, interviews with the MFI board members confirmed these three as the typically most influential issues affecting due payments.

[15] Both defined in Section 2.3: "Group Lending Approaches in Microfinance" (page 35).

The top answer is consistent with the long-established correlation between poverty-stricken areas[16] and the high epidemiological incidence of chronic nutrition and food-related diseases [WHO and FAO, 2003, WEF, 2010]. Those most reported in the surveys include: diarrhoea (26%), cold/influenza (16%), birth complications/fever (13% each), breathing issues/diabetes (10% each), cutaneous diseases/cancer (3% each).

Item	Percentage	Observations
1	*23%*	*diseases and illnesses*
2	*14%*	*lack of business profitability*[a]
3	*11%*	*poor business, or household, investments*
4	*9%*	*family-related problems or costs*
5	8% each	other case-specific reasons, forgetfulness[b]
6	4% each	group issues, move household, got another credit

[a] Missed meetings amount to 15%, but is hereby interpreted as a consequence only.
[b] The latter may either be the case, or a pretext by clients to skip group sanctions.

Table 5.12: Common reported causes leading to individual defaulting

Items two and three in the table above clearly depend on the particular socio-economic circumstances of each affected individual or group. On the other hand, there is a variety of issues influencing lack of profitability, with the most frequently reported in the administered survey being the lack of training (approximately 33% of the total).

The aforementioned reason, incidentally, is also the most frequently mentioned reason for poor investments (20%). The latter issue affecting an individual's ability to pay on time also has a significant percentage attributed to diseases and rising debt[17] (16% each). That is followed by the following reasons: diverted investments (11%), excessive competition and limited market (8% each). All other responses consist of comparatively less important, issues that amount from 1% to 6% of all survey responses.

[16] Afflicted e.g. with issues such as: poor sanitation, malnutrition and lack of clean water.
[17] This increasing of individual debt may be either due to single or multiple credit sources.

In terms of managing debt, in this case study, it is essential to understand the following two events described below. Table 5.13 depicts what microcredit borrowers tend to do when someone from their group misses a meeting. Most of the gathered observations, with the exception of item four and another item (covering defaults) in item 5, relate to other clients evaluating the defaulter and the circumstances surrounding that event. This aspect has been confirmed in interviews with MFI employees and also witnessed, during the administered fieldwork, in credit centres by the author. The survey data is a descriptive list of both consequences and actions deemed relevant by the group participants, which is enforced during the meetings held by the MFI at credit centres.

Item	**Percentage**	**Observations**
1	*38%*	*visit the household (individually or in a group)*
2	*16%*	*wait and check the defaulter's justification*
3	9% each	remind of their obligations, wait for the defaulter
4	6%	expel the defaulter from their group
5	6%	cover a default, depending on circumstances

Table 5.13: According to officers, what clients do when a meeting is missed?

Whilst the previous table dwells on absent participants when collective debt should be managed, Table 5.14 follows through such events by showing what happens when payments are also missed. Absentees are not automatically labelled as defaulters, as the due amount may be paid by others on their behalf. When discussing these findings with stakeholders, a clarification was made regarding Item four of Table 5.13: expelling. The threshold as to whether this should happen seem to depend on the frequency of such event and whether the majority of group participants refuse to support the individual. Yet this remains to be further explored and could be followed-up with future research.

Item	**Percentage**	**Observations**
1	*70%*	*cover defaults collectively*
2	16% combined[a]	remind of their obligations, visit the household
3	*13%*	*seek to charge a group or MFI fine; consider expelling*

[a] Grouped to facilitate interpreting the consequential nature of this observation.

Table 5.14: According to officers, what clients do when a payment is missed?

5.2 Fieldwork Findings: Microfinance Clients

Building upon the knowledge discussed in the previous section, further progress has been made in cooperation with the MFI stakeholders to understand how sanctions are dealt with by groups themselves. This is where the approach of this research reached the 3rd and 4th step depicted in Figure 4.11: "Order of the complete data collection and analysis processes" (page 79). When discussing that group-level fines have been carried out without interference from the MFI (see Table 5.13, page 113), the MFI board members were surprised. It had long been common knowledge to credit officers, but not to the board members. Another discussed aspect is the potential impact of introducing new participants whilst simultaneously assessing older, coexisting, groups funded by the MFI. It is particularly important to assess the impact of policies, e.g. whether evidence of a financially sound clientele is a reliable proxy for individual improvements or simply a statistical reflection of removing under-performing participants from the sample. Clients with greater experience in microfinance tend to be in a better economic situation and have larger disposable income than newcomers [Karlan, 2001, Robinson, 2001, Coleman and Wynne-Williams, 2006, Mukhopadhyay, 2007], so more experienced clients in the MFI are naturally more likely to manage more credit.

In this case study, the aforementioned issue has been taken into account when interpreting what are the feasible, unexpected effects of the unusual 30% client dropout that happened once data collection ceased [Lucas, 2009b]. Leaving is not necessarily due to financial failure: clients may be expelled from groups due to lack of cooperation, or leave voluntarily in search of higher individual credit or better interest rates. Deaths are also part of the exit rates and create a significant impact in groups[18]. Furthermore, one should be aware that this research project may contain an implicit selection bias towards the most successful groups, as those tend to stay longer in the MFI program.

[18] See Table 5.6: "Supportive actions witnessed in microcredit groups" (page 105).

The cross-sectional nature of this research means that different groups have been surveyed simultaneously. Thus findings are a subset snapshot of what the total credit client population actually is. A repeated cross-sectional type of longitudinal approach[19], would have allowed analyses of the MFI groups over longer periods of time. Yet that would have also required substantial larger funding and more time. Both were unavailable, so individuals have not been financially and behaviourally tracked within groups. The criteria used by credit officers to choose which clients to survey[20] plus the perceived relationship between group behaviour and their finances[21] are suggestive that the research design resulted in the data collection of the rather more successful MFI groups.

If the design had been focused on analysing the broader impact of microfinance to mitigate poverty and inequality, that would have required a longitudinal approach to track clients that have left the MFI. Thoroughly assessing the impact of microfinance programs, i.e. both at micro (client) and macro (community) levels, can be prohibitively time consuming and expensive, as one shall seek to strike an appropriate balance in order to keep the analysis within both what is manageable and what is representative.

The client survey[22] focused on collecting structural data on how groups are composed and how they monitor each other during credit cycles. One interesting aspect that emerged from fieldwork is the composition and location of surveyed groups. Questions such as "Who would you ask personal advice?" and "With who would you collaborate in a business activity?" allowed the identification of up to three people in their networks. It is assumed that the order of answers roughly corresponds to the relevance of each person to the interviewee. This premise is only pertinent to interpret the data on the next page. Table 5.15 depicts that a majority (86% in total, with 50% aggregate) of surveyed clients had relatives in their business network who were also in their groups.

[19] As introduced in Section 4.2: "Design of Data Collection and Analysis" page 80).
[20] Table 4.2: "How credit officers chose the 600 surveyed clients [Lucas et al., 2008]", page 82
[21] These aspects are discussed later in this section in greater detail.
[22] Available as the 2nd questionnaire in "Appendix I: Fieldwork Surveys" (176).

This finding is significant as it directly violated an existent MFI rule that prohi-bited relatives forming credit groups[23]. This case study suggests the importance of cultural identity in encompassing the informal bound between microcredit group members. There is relevant evidence[24], validated by stakeholders, backing the suggestion that social conventions can vary according to group composition. This is based on the collected survey data and interviews with stakeholders, in the form that: (a) rural groups, due to their remote location, would tend to be formed by family members and employ more social pressure to drive out defaulting behaviour; whilst (b) urban groups tend to contain more unrelated neighbours who prefer to administer group-level fines.

Business network[a]	**# of groups (percentage)**[b]	**Aggregate**[c]
relative	225 (86%), 105 (40%), 56 (21%)	386 (50%)
neighbour	76 (29%), 65 (25%), 38 (15%)	179 (23%)
friend	78 (30%), 82 (31%), 46 (18%)	206 (27%)

[a] Each analysed property is mutually exclusive, with approximate percentages.
[b] Correspondingly: first, second and third unique set of answers.
[c] Data grouped per category, per topic (business network in this case).

Table 5.15: Non-aggregated composition of the clients' business networks

Table 5.16 below depicts data of similar nature, when compared with the previous table, however focusing on the advice network. Once again the majority (64% in total, with 58% aggregate) indicated their relatives as being those whose surveyed subjects rely most.

Advice network[a]	**# of groups (percentage)**[b]	**Aggregate**[c]
relative	167 (64%), 106 (41%), 39 (15%)	312 (58%)
neighbour	21 (8%), 33 (13%), 12 (5%)	90 (17%)
friend	45 (17%), 47 (18%), 28 (11%)	120 (22%)

[a] Each analysed property is mutually exclusive, with approximate percentages.
[b] Correspondingly: first, second and third unique set of answers.
[c] Data grouped per category, per topic (advice network in this case).

Table 5.16: Non-aggregated composition of the clients' advice networks

[23] An attempt to lessen the patriarchal influence in deprived families (8th page from 180).
[24] See e.g.: the discussion of the tables explained on page 113 and the figure on page 129.

In both aforementioned tables, a minority (respectively less than 1% and then up to slightly higher than 2% indicated people who are in the same group and also working in the same profit-generating activity. Considering the less frequent answers in the second and third sets, it is possible that surveyed subjects may have either: avoided providing more information about their peers, or indeed had no further information to provide. The assumption mentioned on page 116 (of having indirectly collected answers regarding people in order of importance) remains feasible, as whichever the case, this remark would not change the previous paragraph. As the surveys were, at the time, administered to clients belonging to various geographically distant credit centres[25], no social network containing promising structures could be constructed. That is because the cross-sectional networks were too fragmented and contained too few links and nodes for an Exponential Random Graph Model approach. It would be worth to develop a research project to further explore aspects of social network analysis, mentioned in Section 6.1.1: "Contribution to Knowledge: Conventional Behaviour" (page 168), as a way to aim shedding new light on how the structure of groups change over time.

The discussion on the next two pages builds upon data regarding the actions most associated with what clients do when a client has missed meetings (i.e. Table 5.13: "According to officers, what clients do when a meeting is missed?" and/or payments (i.e. Table 5.14: "According to officers, what clients do when a payment is missed?"), both on page 113. Some actions have been witnessed in practice by the author during fieldwork and all have been confirmed by stakeholders as a set of feasible group-level social conventions for coping with defaulters. Conventionalised behaviour seems to evolve according to past individual experiences and through recommendations flowing between microfinance groups. The conjecture is that clients can learn in this way, including –for instance– how to administer social and financial sanctions. The existence of emergent strategies for dealing with defaulters is evidence of self-organisation within the microfinance groups.

[25] The approach and criteria for choosing surveyed subjects (i.e. Table 4.2) are on page 82.

The second survey was administered to credit clients. It contained two similar questions made to credit officers in the first administered survey. The results of these are summarised below in two tables, one regarding actions clients engage when a meeting is missed and the other regarding reported actions when a payment is missed. Interestingly, both tables contain clients stating that such events never happened.

The most cited action, with regards to what clients do when a meeting is missed, has a similarly high percentage if compared to the response obtained from credit officers [26]. The second item can be interpreted as being linked to the concept of social collateral, as the MFI rationale is to encourage cooperation amongst micro credit clients that are in need of relying on each other in order to access financial services.

Item	**Percentage**	**Observations**
1	*34%*	*visit the household (individually or in a group)*
2	*19%*	*discuss how to cooperate collectively*
3	*10%*	*insist with finding the client*
4	8% each	seek to charge a fine, find out the reason
5	6% each	never happened, remind of their obligations

Table 5.17: According to clients, what is done when a meeting is missed

The top two most cited actions, with regards to what clients to when a payment is missed, have similarly high percentages when compared to the responses from credit officers[27]. Other common actions include attempts to charge fines, visiting the defaulter's household and somehow trying again to interact with the group member.

Item	**Percentage**	**Observations**
1	*58%*	*cover defaults collectively (when the defaulter is ill)*
2	*13%*	seek to charge a group or a MFI fine
3	*11%*	*visit the household (individually or in a group)*
4	*6%*	*never happened*
5	4% each	*insist with the defaulter, remind of their obligations*

Table 5.18: According to clients, what is done when a payment is missed

[26] Table 5.13: "According to officers, what clients do when a meeting is missed?" (p. 113).
[27] Table 5.14: "According to officers, what clients do when a payment is missed?" (p. 113).

The timely provision of reliable new information to stakeholders and policy-makers, in this and another twelve international case studies[28], seem to date best achieved through fieldwork –or similarly commissioned research. Simulation models, regardless of how detailed, represent social phenomena in a more formal and synthesised way than most descriptive (i.e. text-based) or statistical accounts. The observed stakeholder preference in this case study has clearly been simplicity to explain concepts and illustrate the social conventions in question. The methods and approaches employed to implement these accounts into an ABM were initially completely foreign to the MFI stakeholders. Thus this prompted a sustained effort, during the research development, to meaningfully engage them in the modelling process and clarify every difficulty along the way.

Figure 5.18 below depicts a significant number of groups concentrated in few centres. Only a small number (15) of these repeat in the collected data. This is an indicative that most of the credit officers adhered to the agreed criteria to select surveyed subjects[29]. There are more locations plotted in Figure 4.10: "Raster KML plot of the 21 client locations surveyed during fieldwork" (page 77) as clients, despite belonging to one of the six centres plotted below, may not live exactly where the credit centre is located.

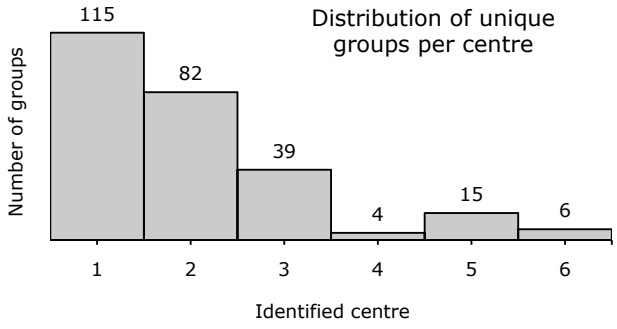


Figure 5.18: Unique groups associated with unique centres[a]

[a] 15 groups appear more than once in the dataset. Average number of clients per centre: 3.5

[28] Discussed in Section 3.2.2: "Challenges in Simulating Social Phenomena with ABM" (page 61).

[29] See discussion in Section 4.2: "Design of Data Collection and Analysis" (page 81).

All 600 surveyed clients were identified according to location, name and membership number. That allowed processing financial data of all 261 identified groups, of which 98% (256) paid on time, 72% (190) being rural, 37% renewed the same credit and 44% had credit equally distributed amongst members. Groups varied from a minimum of three to the maximum of seven. The average size is four, with a standard deviation of 1.21. About 21% of the surveyed groups no longer existed by the end of the data collection process. This sample is relatively close to the 30% client exit rate registered by the MFI after that period. Some of the circumstances that contributed for that include:

- (a) lack of security to manage credit centres, as some fieldwork was delayed due to organised theft (occurring during fieldwork) targeting en route MFI officers,

- (b) sharp increase in competition for clients with other MFIs (the main competitors included the Grameen Bank, FINCA and Compartamos [CGAP, 2007])[30],

- (c) impossibility of the MFI to offer higher credit to their most successful clients.

Next page's Figure 5.19 depicts proportionally fewer groups managing credit with more than five members. In the figure one can see two group structures represented: initial and final. Some (58) renewed credit whilst the data collection was being administered –whilst others (259) were in credit cycles. 41 out of 56 groups reduced the number of participants during the data collection process. The implicit suggestion, leaving aside that groups may not have finished their credit cycles during fieldwork, is that stability is important both to the MFI and the clients. As previously discussed, expelling a client from a group is not simple. That depends on the self-organised group evaluation mechanisms, such as the one presented based on Figure 5.24: "A schematic representation of the clients' decision-making" (page 129), to manage the instability inside groups due to the removal of individuals.

[30] Profitability from high interest rates has been strongly criticised by non-profit driven MFIs.

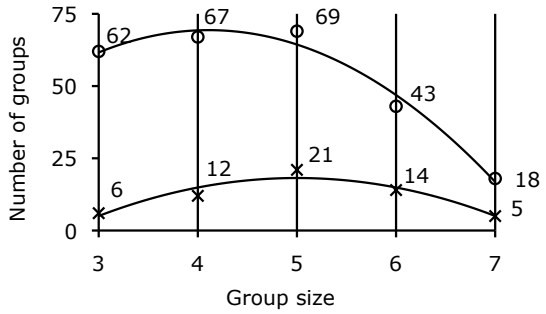


Figure 5.19: Distribution of group size amongst surveyed clients[abc]

[a] Deviation (R^2) is 0.90, suggesting that group size distribution is rather regular.
[b] Total of 259 initial groups, as not all members could be identified in the remaining cycle.
[c] Top values are initial groups (259), whilst the bottom ones are final groups (58).

These findings have been generally common knowledge to the credit officers and clients, but not to the MFI board members. Despite good work conditions and relationships with employees, the detailed information about how groups behave was not being institutionally absorbed at every level. Not having enough time for doing all that is requested of credit officers[31] may be one of the compounding elements influencing the lack of communication with the board. The erratic level of post-credit consultancy provided to clients, mentioned on page 108, is an issue that could be further researched.

Group status	**Scale**	**Status of collective credit**
any change	58 (100%)	avg. decrement, increment (1.5%)
removed members	41 (70%)	23 kept (56%), 18 reduced (43%)
added members	17 (30%)	3 kept (17%), 14 increased (82%)

Table 5.19: Structural and financial statuses of surveyed groups

Table 5.19 depicts that, amongst groups that change, removal of a member is relatively uncommon regarding the total number of surveyed groups (261). Average change tend to involve one person: both increment and decrement of standard deviations are about 0.8. Maybe due to the small sample, financially there seems to be little advantage to shrinking groups, as credit is kept largely equal despite removals. Most groups that got bigger have increased the total amount of credit –yet a small percentage did not.

[31] Table 5.9: "Disadvantages of the framework, according to credit officers" (page 108).

In interviews, carried out as part of the adapted EDTM[32], credit officers and MFI board members commented that expelling is generally a difficult event for credit groups to handle, particularly when there are outstanding debts. Such events require a fresh social reaffirmation[33] from group members in order to maintain cohesion and stability for keeping up with future payments. Disrupting the otherwise normal course of action within MFI groups is probably undesirable, given that the discussed social conventions[34] prioritise conforming individuals to what is generally seen as acceptable behaviour. Similar arguments have been made elsewhere, such as in [Anthony, 2005, Ledgerwood et al., 2013] where the authors discuss that individual clients who miss meetings, and/or payments, can disrupt the collective access to capital.

After carrying out the fieldwork, it became clear that an unexpected high number of clients left the MFI. That did not affect this case study, as not many surveyed groups[35] completed their full credit cycle during the fieldwork. In the studied MFI, experienced clients are those who tend to –most often– contact potential newcomers, as there are no MFI advertisements or events to attract new clients[36]. For this reason, recovery of the client base for this particular MFI has been a rather slow process.

The stakeholders suggested, during the interviews, that there seems to be a learning process amongst groups, which may help the propagation and internalisation of social conventions. This suggestion is based on all the survey and fieldwork evidence presented in this chapter and seems likely to be confirmed if, in the future, another research is carried out with this intention. If this suggestion is indeed ratified, this would be another research finding with useful potential for both practitioners and academics interested in better bottom-up understanding of microfinance policy-making.

[32] See Section 4.17: "The adapted EDTM development cycle" (page 93).
[33] Confirming, or re-establishing, the group conventions for dealing with defaulters and debt.
[34] Figure 5.24: "A schematic representation of the clients' decision-making", p.129.
[35] 58 in Figure 5.19: "Distribution of group size amongst surveyed clients" (page 121).
[36] Apart from the beginning of the MFI operations, as then there was a need to expand.

As clients are not required to manage debt and credit at centralised branches, credit officers travel periodically to where groups live to set up a local and temporary credit centre[37]. This process is potentially key, yet it remains to be further assessed in the future research: whether the internalisation and sharing of knowledge regarding which social conventions are likely to be adopted by groups indeed differ by location. Perhaps there would also be interesting variations in terms of this diffusion in rural and urban groups[38]. The suggestions about the learning process is that different social conventions are tested over time by clients, with the objective of managing defaulters and debt throughout the validity of credit. Then gradually the less effective strategies would be abandoned in favour of the alternatives that provide better results for the group.

From this paragraph onwards, this section continues with findings from the financial analysis of the surveyed clients, both in terms of collective and individual credit. Tables 5.20 and 5.21 synthesise the state of all credit analysed during fieldwork. As one can see in Table 5.20 below, there are considerable differences between the minimum and maximum credit that individuals received from the MFI. The variation is particularly relevant in this case study, as the microfinance framework in question is focused at providing credit to the poorest in the region of Chiapas, Mexico. Considering that values vary substantially, notice that some surveyed individuals (either in initial or final groups[39]) are relatively wealthy given the restrictions of their economical context.

Credit feature	**Minimum**	**Average**	**Maximum**	**Std. dev.**
full dataset[a]	$ 500.00	$ 5,600.04	$ 39,538.00	$ 8,422.52
individual (initial)	$ 1,000.00	$ 3,357.80	$ 14,600.00	$ 1,739.34
individual (final)	$ 1,000.00	$ 4,194.91	$ 14,500.00	$ 2,210.25

[a] I.e., all those (surveyed or not) in the cross-sectional dataset provided by the MFI. Exchange rate: one USD = 13 Mexican Pesos.

Table 5.20: Surveyed individual credit in Mexican Pesos

[37] The location is determined according to the clients' locations. For example, see Figure 4.10: "Raster KML plot of the 21 client locations surveyed during fieldwork" (page 77).

[38] As alluded to the suggestions discussed in terms of behavioural conventions (page 129).

[39] That is, as explained in the first paragraph of page 121, those belonging to groups that renewed credit (final) and those still in credit cycles (initial) during the fieldwork administration.

This fact suggests that a number of surveyed clients have long been working with the MFI. Otherwise, it would not have been possible for these individuals to manage credit that is much higher than the minimum initially provided to newcomers. As a result, surveyed groups depicted in Table 5.21 also contain diverse financial statuses. The exchange rate is the same as in the previous table, i.e. one USD = 13 Mexican Pesos. The standard deviations are not necessarily high, as the surveyed groups differ over time[40].

Credit property	**Minimum**	**Average**	**Maximum**	**Std. dev.**
group (initial)	$ 3,000.00	$ 15,780.77	$ 73,000.00	$ 8,921.58
group (final)	$ 3,000.00	$ 9,064.47	$ 87,000.00	$ 11,305.53
credit increase	$ 3,000.00	$ 3,283.70	$ 73,000.00	$ 2,383.95

Table 5.21: Surveyed collective credit in Mexican Pesos

Figure 5.20, on the next page, depict a general tendency of overall collective credit amounting to the lower end of the scale and that groups managing high amounts of credit are rather scattered. This is not surprising, given that the standard deviations shown in Table 5.21 above are high in both initial and final group configurations. Thus one can consider that –proportionally to this sample– not many surveyed groups registered a total amount of credit that is considerably higher than the corresponding averages in the table above.

Analysing in greater detail the circumstances of clients with high credit could provide further suggestive evidence to explore the suggestions [41] that the top, most successful, ones are also the most likely to leave the MFI in search of higher individual credit or better interest rates. This is important as, contrasting with the early developments of microfinance, the current trend is to keep clients by allowing them to manage larger amounts of credit –instead of losing (or "graduating") them to traditional banking services [UNITAR, 2013, Ledgerwood et al., 2013].

[40] See Figure 5.19: "Distribution of group size amongst surveyed clients" (page 121).
[41] Mentioned first in Section 5.2: "Fieldwork Findings: Microfinance Clients" (page 114).

That is important, as the most successful entrepreneur MFI clients have difficulties to find others with comparable credit to form new groups. Demand for higher individual credit seems to be evident amongst urban clients, where financial sanctions also seem to be employed more efficiently than rural groups seemingly preferring social sanctions.

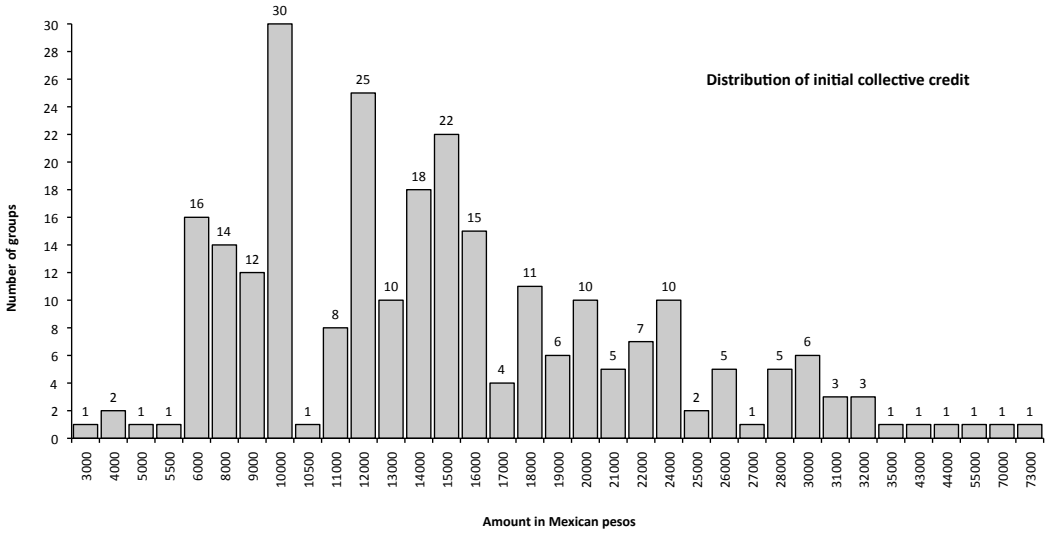


Figure 5.20: Distribution of the average initial collective credit (surveyed groups)

The figure below shows that most clients have individual credit at the scale's lower end. One can see that there are fewer, yet relevant and representative, number of individuals with much more credit (i.e. above $30,000). The plot contains data of all clients in the cross-section extracted from the financial database, which include the surveyed groups.

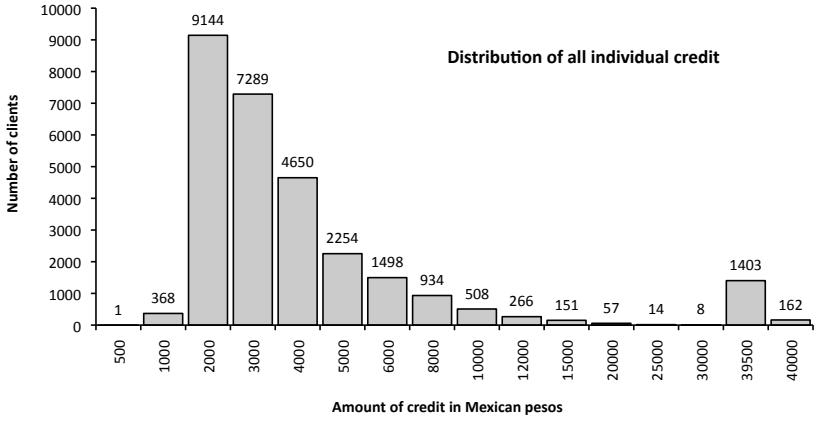


Figure 5.21: Distribution of individual credit (full cross-sectional dataset)

Figure 5.22 below depicts how individual and group debts compare regarding credit. This plot complements Table 5.20: "Surveyed individual credit in Mexican Pesos" and Table 5.21: "Surveyed collective credit in Mexican Pesos" (both on page 123), which is aimed at providing a single plot of all collective and single credit instalments.

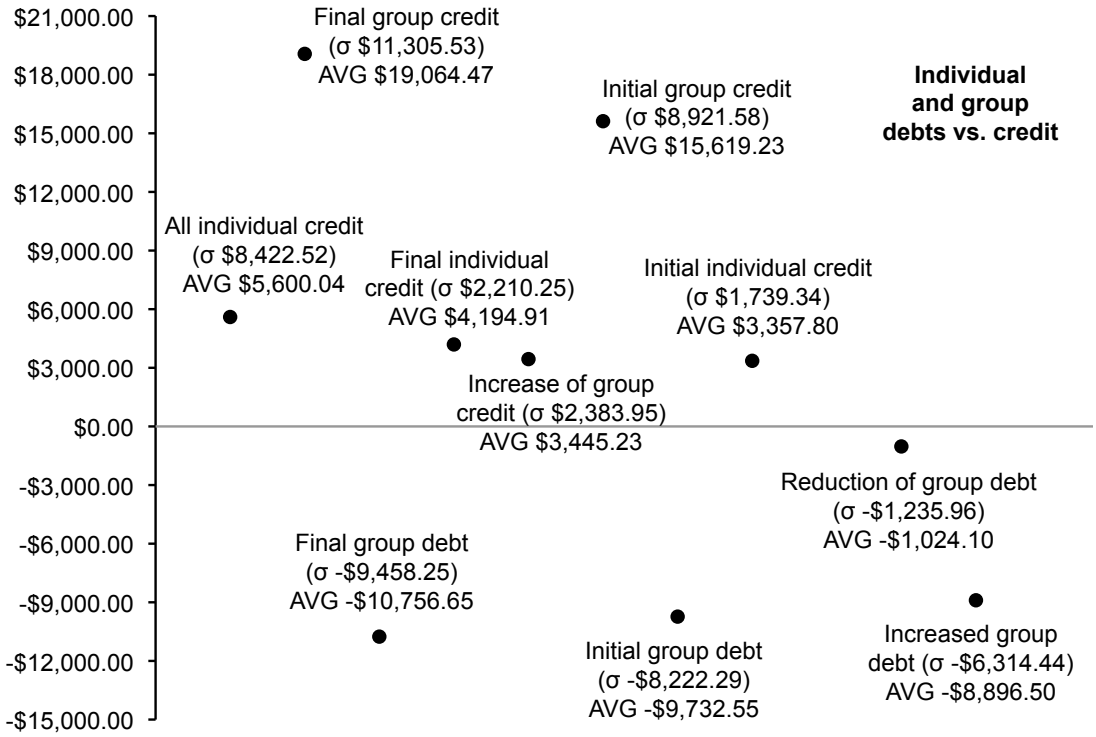


Figure 5.22: Overall distribution of surveyed debts and credits

Considering the transitional state of the surveyed groups during fieldwork, note that:

- the financial state of groups tend to remain stable, as despite the high standard deviation on the increase of group debt (bottom right data label), the initial and final group debts do not differ substantially (bottom left and centre data labels);
- the difference between initial and final group credit (top left and centre data labels) is significant, which indicates –despite the high variance within groups– that renewed collective instalments were generally more successful than before;
- in terms of final and initial individual credit, one can see greater variations –which are particularly evident in the increasing standard deviations– due to the skewed nature of the cross-sectional dataset shown in Figure 5.21 (on the previous page).

5.3 EDSM Assumptions and their Justification

Due to the usually significant cognitive gap between modellers and the social phenomenon stakeholders[42], the author considered important to highlight how the participation of stakeholders can considerably facilitate the development of both the adapted EDTM[43] and integrating the resulting representation in the EDAM[44] approach to build an ABM. This is because stakeholders understood –as the research progressed– how data was being collected, analysed and used by the modeller. Such regular updates by the modeller –in my experience– promotes a productive engagement with stakeholders, as the original gap between both reduce over time as part of this ongoing interaction.

The EDTM presented on the next page has been built based on the qualitative findings extracted from surveys, particularly Table 5.13: "According to officers, what clients do when a meeting is missed?" and Table 5.14: "According to officers, what clients do when a payment is missed?" (page 113), and validated with observations and interviews during fieldwork. This is the result of having carried out the discussed adaptation of the EDTM, in which a sequence of survey questions has been administered to understand what individual clients actually do to cope with in key circumstances[45] in their microfinance groups.

Due to the nature of the chosen approach to categorise the collected qualitative data[46], different concepts could have been extracted from the survey to develop the EDTM. The result presented in this thesis is in line with the original EDTM methodology, intended to provide a composite, cross-sectional, culturally-grounded representation of a decision-making process. The frequency of items in the identified categories have been used to guide the representation of behaviour in the form of events registered by each individual agent regarding another agent in the ABM simulating MFI clients.

[42] In terms of one not being as experienced or as familiar with each other's expertise.
[43] See Section 4.3.1: "Developing an Ethnographic Decision Tree Model (EDTM)" (page 91).
[44] Discussed in Section 4.3: "Evidence-Driven Approach to Modelling (EDAM)" (page 86).
[45] Which consist of missed meeting and/or missed payments, as highlighted by the data.
[46] As discussed in the previous Section 5.1: "Fieldwork Findings: Credit Officers" (page 104).

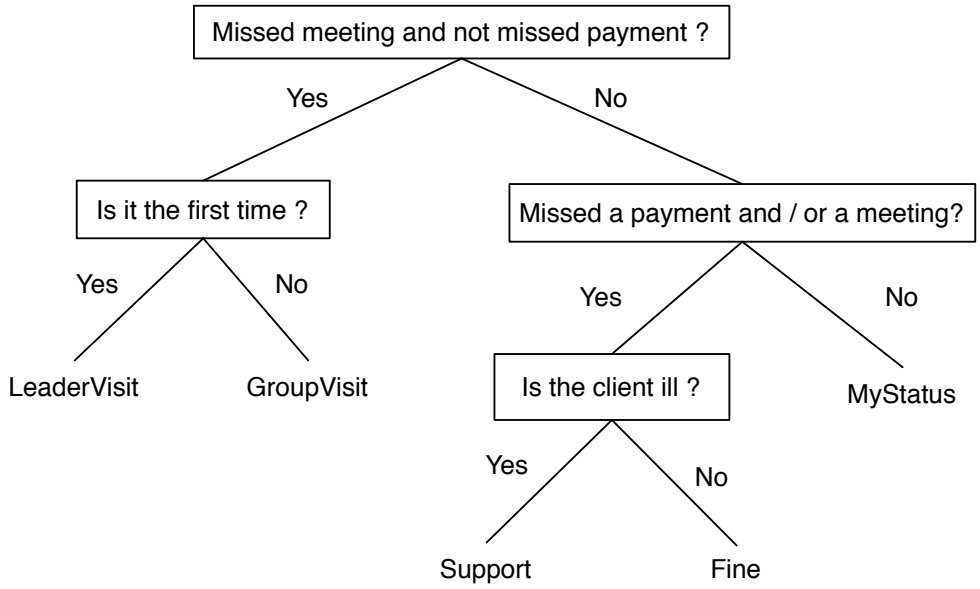


Figure 5.23: The proposed EDTM of decision-making within MFI groups

Each ramification is tested in the ABM, per credit cycle and per agent in the simulation, resulting in an event as described in Table 5.26: "Summary of all possible events in the "MeetingTrack" (page 143). The EDTM, which has been deemed plausible by interviewed stakeholders during fieldwork, is based on assumptions and stylised facts extracted from:

– Tables 5.13: "According to officers, what clients do when a meeting is missed?", and 5.14: "According to officers, what clients do when a payment is missed?" (page 113),

– Tables 5.17: "According to clients, what is done when a meeting is missed", and5.18: "According to clients, what is done when a payment is missed" (page 118),

– and Table 5.6: "Supportive actions witnessed in microcredit groups" (page 105).

The figure on the next page illustrates the processing stages of the EDTM presented above. It is thus a schematic representation of how the surveyed groups deal with adversity. In the diagram, one can see the order and structure of social conventions, regarding how MFI clients deal with the penalisation –or support– of defaulters in their groups.

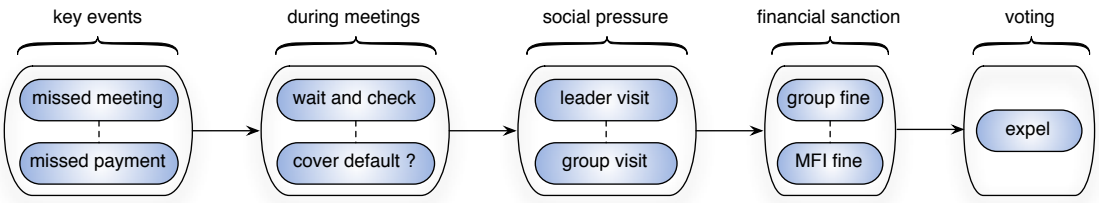


Figure 5.24: A schematic representation of the clients' decision-making

There are two key events that are evaluated by group participants: missed meetings and missed payments. Missing the former does not necessarily imply defaulting, as the due quota may have been paid in advance to the group or brought to the credit centre by someone else. In this regard, a promising trial for the MFI would be to allow payments via mobile networks[47] by, perhaps, according to how successful each client is.If a group member is missing in a meeting, other matters –that are not dependent on that person– are usually dealt with. After waiting for the defaulter, and if the absentee is still incommunicable, the outstanding quota is likely to be covered by the other group members[48] –during the ongoing meeting– in order to avoid a fine from the MFI. These tends to be higher than group-defined ones, as it will effectively affect all group members. It is during meetings that participants assess what to with a defaulter[49]. Two empirically grounded suggestions are proposed, based on the fieldwork findings.

- (a) social sanctions (i.e. pressure) may be preferred by microcredit clients in rural areas (due to its potential efficacy in groups formed mainly by relatives);
- (b) financial sanctions (i.e. fines) may be preferred by microcredit clients in urban areas (due to its efficacy in groups formed by unrelated neighbours).

These suggestions are supported by the MFI stakeholders as plausible due to the assortative nature of their group formation and likelihood that this process is bound by geographical distances[50]. Both suggestions remain to be tested empirically. Social sanctions are exerted either by the group leader visit or a group visit to the defaulter. Stakeholders also mentioned the difficulty of expelling a client, which is sometimes at stake if their future collective success depends on recurring defaulter in their group.

[47] Assuming that the relatively high operational costs are somehow overcome appropriately.
[48] Sometimes one single participant, with much more credit than others, covers the default.
[49] To proceed with a social or a financial sanction, depending on the circumstances.
[50] Often large distances in difficult terrain: see Figures 4.10 (page 77) and 5.25 (page 130).

Figure 5.25 depicts the distribution in kilometres of all unique routes between fieldwork locations[51]. Most groups are located far from each other and many are not easily accessible –particularly as rural clients tend not to be frequent users of paid transportation. The lack of good infrastructure and affordable transportation also seem to affect the ability clients have to trade goods without dealing with exploitative intermediaries, who have resources to travel where clients live and operate enterprises.

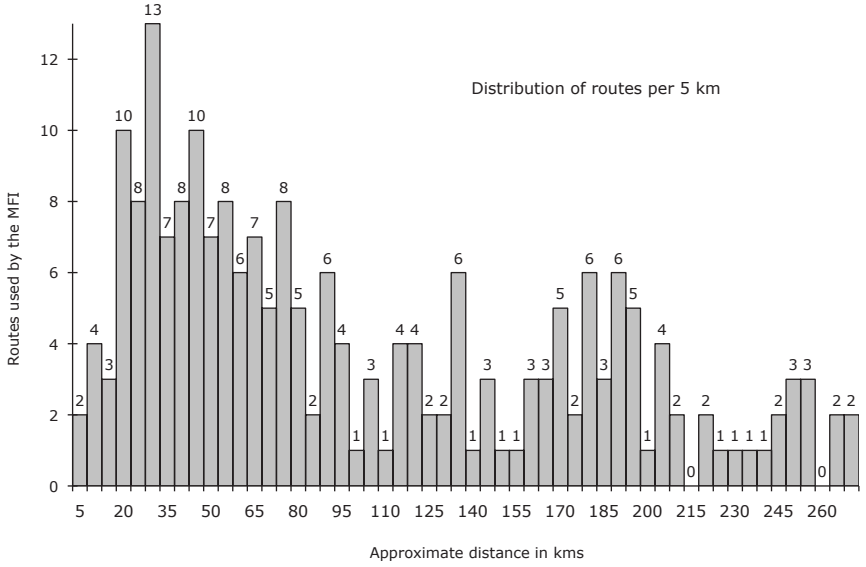


Figure 5.25: Histogram of all distances covered during fieldwork[a]

[a] Average of 99 km, min. of 1.31 km, max. of 267 km, standard deviation of 72 km.

The average distance from the MFI headquarters, San Cristóbal de Las Casas, to the other surveyed sites is about 73 km. The standard deviation is 57 km, as one can see above, the total route lengths between clients vary considerably. Often officers use cars provided by the MFI to reach every served credit centre, distribute credit and collect debts to funded groups. However, if the client's location can be easily reached via public transport, that option would also sometimes be used by the institution's employees.

During fieldwork, all bookkeeping by credit officers was made on paper and the data was later summarised into the MFI system by themselves at their headquarters. This has been a simple and effective way of maintaining their records up-to-date, but is likely to be supplanted by the MIFOS.org open source customer relationship system.

[51] Figure 4.10: "Raster KML plot of the 21 client locations surveyed during fieldwork",p.77.

Being able to keep a detailed record about actions within groups (e.g. why certain losses have been covered and by whom) would help interpreting both the short and long-term effects caused –or reinforced– by these. Such knowledge would also be useful to continuously refine the ABM[52], and validation of results[53] presented in this thesis. Having such detailed time series on how credit groups self-organise would strengthen the foundations to understand –over longer periods of time– the applicability of every registered event amongst clients[54] with regards to what happens internally in groups.

Due to the cross-sectional nature of this fieldwork, it is necessary to acknowledge the limitations of extrapolating –or generalising– implications of this research beyond what is discussed hereby. MFI rules and geographical circumstances can play similar roles as those observed in this fieldwork[55], in the sense of allowing or constraining actions. However other unobservable local factors may also influence the shaping of social conventions between group participants in ways that are unexpected to the institution.

Another aspect that is also worth mentioning that the MFI board of directors, although aware of the cautious remark made at the end of the previous paragraph, they did perceive fieldwork findings with less scepticism than the model results obtained with the ABM. Every fieldwork report[56] contained new and detailed information about relevant, but previously relatively unknown, aspects regarding the group self-organisation. Some of the findings presented in these documents were promptly regarded as useful contributions to improving some of the existing MFI policies[57]. So this stakeholder assessment has probably been influenced by their general greater familiarity with the concepts and processes discussed during the data collection[58], plus the fact that the stakeholders participated directly in defining the questions used in the surveys.

[52] See Section 5.3.2: "The Evidence-Driven Simulation Model (EDSM)" (page 132).
[53] Discussed in Section 5.4.1: "Discussion of the EDSM Results" (page 147).
[54] See Section 1.1: "Objectives and Contributions to Knowledge" (page 12).
[55] See [Karlan, 2007] for a discussion on aspects of cultural and geographic proximity.
[56] Discussed first in Section 4.1: "The MFI Context during Data Collection" (page 76).
[57] See Section 5.4.2: "Modelling Guidance and Impact on Policy-Making" (page 163).
[58] See Figure 4.11: "Order of the complete data collection and analysis processes" (page 79).

5.3.1 The Iterative Process of Utilising Findings

According to the illustration in Figure 4.11: "Order of the complete data collection and analysis processes" (page 79), the research design was carried out by following a sequence of surveys that complemented the understanding of the MFI case study. Then interviews were carried out with random stakeholders during the one month fieldwork in Mexico, regarding each of the findings discussed in Section 5.1: "Fieldwork Findings: Credit Officers" (page 101)" and Section 5.2: "Fieldwork Findings: Microfinance Clients" (page 114)". Both credit officers and credit clients confirmed that these are results in accordance with their experience. After this step, the more generic illustration contained in Figure 5.24: "A schematic representation of the clients' decision-making" (page 129) was also presented and discussed with the stakeholders. Then a more detailed representation of the mechanism to internally manage and penalise individuals was proposed in the second fieldwork report. That was then refined into the representation shown in Figure 5.23: "The proposed EDTM of decision-making within MFI groups" (page 128).

5.3.2 The Evidence-Driven Simulation Model (EDSM)

The exploratory simulation modelis based on the collected and analysed data, described in Chapter 5: "Research Findings" (page 100), and is aimed at simulating the occurrence of events within credit groups based on the EDTM proposed to represent conventional behaviour amongst MFI clients in this case study[59]. In total 41 configurations have been tested with the ABM, which generated non-aggregated data about each individual agent, allowing the inspection of the dynamics at the micro scale. This data has been aggregated so that the macro patterns could be analysed.

[59] See section Fieldwork Findings: Credit Officers (page 101) and Clients (page 114).

The results of these analyses are described in Section 5.4.1: "Discussion of the EDSM Results" (page 147). Registered events during simulations (i.e. missed meeting and / or payment) are endorsed, from the perspective of individual agents, as being either acceptable or unacceptable according to the EDTM. Analysing the total number of events and endorsements did not help to explore the configured groups over time, so instead focus has been on the averages and standard deviations[60]. The developed ABM is a form of exploring the interaction amongst agents equipped with the same EDTM, with no intention of forecasting. The interaction during simulations takes place during the scheduled credit meetings, prompting each agent to go through its own memory in search of previous event registries given to events regarding each specific group participant. Every agent has also a randomly assigned list of tolerances about each group member, which remains fixed until the end of a simulation. No implementation of individual fitness has been done in the sense of optimisations, as events are just individually endorsed either as acceptable or unacceptable, depending on each configured agent and circumstances[61].

The agents' sensing ability is limited to sequentially consulting –in different order per consultation– the defaulters' circumstances (i.e. the parameters) during a meeting. And bearing in mind that there is no evidence from the EDTM to guide the modelling of certain features, stochasticity has been used in the following aspects of the ABM:

- collective incidence of illness, unprofitability or bad investment [Lucas, 2009b][62];
- processing order of such conditions, as fixing that could create path-dependency[63];
- when agents, tagged as potential defaulters, may default or miss meetings.

[60] See Section 5.4.1: "Discussion of the EDSM Results" (page 147).
[61] See Section 5.3.3: "Structure, Processes and Parameters of the EDSM" (page 136).
[62] See Figure 2.6: "Threats close to a poverty line, adapted from [Churchill, 2007]" (page 44) and Table 5.12: "Common reported causes leading to individual defaulting" (page 112).
[63] See Section 4.3.2: "Implementing the EDTM into the ABM simulation" (page 95).

The research throughout this thesis is focused on describing and exploring conventional social behaviour, as this feature is pervasive in microfinance due to the social collateral concept that is central for harnessing cooperation in microfinance[64]. Whilst collecting and analysing data, it has been observed how institutional rules (i.e. the conditions to repay credit) imposed by the MFI can interplay with the emergent (informal) cooperation and penalisation strategies managed by group members[65]. In other words, apart from formal credit rules, there are also group-level criteria for dealing with defaulters and debt. Understanding these conventionalised behaviours in detail was deemed an asset by the MFI board members and this also helped in the ABM modelling process. One of the main findings was the elucidation of how institutional (top-down) policies may facilitate, or disrupt, the success of groups in relation to their organisation[66]. Despite being central to microfinance, the available literature suggests that often MFI practitioners lack thorough understanding of how conventional social behaviour amongst group members affect their collective responsibility to manage credit[67]. This happens partially as collecting and maintaining this type of data is time-consuming and drains resources from other MFI areas that deserve prompter attention and resources.

In case an a MFI has never systematically collected qualitative data from its credit officers or clients, it can be considerably troublesome to administer questionnaires to many hundreds –or thousands– quickly enough for timely analysis and presentation of findings. This is particularly evident when institutional resources have been stretched close to full capacity with other costly tasks, as then their financial portfolio may be at risk due to such extra expenses. Despite these being potentially useful, there is no guarantee that such research should produce knowledge to stakeholders that is directly relevant for policy-making. Those are one of the reasons that compelled the MFI to collaborate with the development of this research thesis, as the research proposal externally covered all the involved extra time and expenses during the project.

[64] See the discussions put forward in Chapter 2: "Social Enterprise" (page 17).
[65] See discussion in Section 5.2: "Fieldwork Findings: Microfinance Clients" (page 114)
[66] Figure 5.24: "A schematic representation of the clients' decision-making", p.129.
[67] This is discussed in Section 2.3: "Group Lending Approaches in Microfinance", page 31.

Evidence from this case study suggests that there may be rather stable group-level behavioural conventions, including shared values and processes, contributing to sustain long-term cooperation and management of penalisations within the surveyed microcredit groups.

Such analysis of the microfinance clientele was useful both for guiding the modelling discussed in this thesis and also provided the local policy-makers with new information about their clients. Details from Section 5.1: "Fieldwork Findings: Credit Officers" (page 101) were particularly informative for this. Other relevant insights were obtained by analysing both the qualitative and financial findings with stakeholders[68]. This included conventionalised behaviour for administering: sanctions (e.g. via social pressure or group-level fines or expelling) and cooperation (via covering individual defaults)[69].

Another conjecture that emerged form the analysis is that the number of relatives and neighbours seem to depend on group location, and that lead to the suggestions as to what is pivotal to understand in terms of acceptable –or desirable– behaviour. According to the collected data rural groups tend to contain relatives, whilst urban ones neighbours (see page 168). This has been alluded to the suggestions discussed in terms of behavioural conventions (page 129).

[68] See Figure 4.11: "Order of the complete data collection and analysis processes" (page 79), Figure 4.17: "The adapted EDTM development cycle" (page 93) and
Figure 4.14: "Evidence-Driven Approach to Modelling (EDAM) [Lucas, 2011]" (page 88).

[69] See Figure 5.24: "A schematic representation of the clients' decision-making" (page 129) and Section 5.2: "Fieldwork Findings: Microfinance Clients" (page 114).

5.3.3 Structure, Processes and Parameters of the EDSM

Figure 5.26 below illustrates how the EDSM operates. The agent parameters are configurable according to the boundaries set by the EDTM developed based on the analysed data. These include the group circumstances listed in Table 5.23: "Configurable parameters for group circumstances in the EDSM" and financial aspects listed in Table 5.25 "Configurable financial parameters in the EDSM" (page 137).

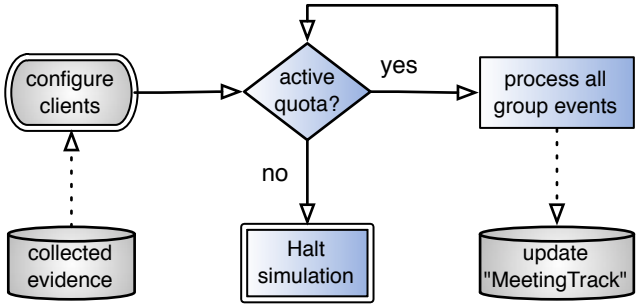


Figure 5.26: Diagrammatic representation of a EDSM simulation run[a]

[a] Dotted lines indicate either database queries (evidence) or insertions (simulation results).

The number of "Repayments"[70] effectively allows agents to process a proportional number of registered events about each other[71] and update the agent individual "MeetingTrack" data structure[72] at runtime. I.e. a simulation with more repayments and clients facing adversity will probably lead to more events. Once all iterations are processed, the simulation is over and the user is then able to analyse results by interpreting the detailed log of that particular simulation run or visualise aggregations of the former.

Table 5.22 on the next page contains the parameters regarding a simulation run. It is possible to change values of these parameters whilst running the model, but that would too reflect in the obtained results. This kind of experiment is probably best suited for educational tests but not for analysing the overall behaviour of a given configuration.

[70] 12 or 24: as in Table 5.25: "Configurable financial parameters in the EDSM" (p. 139).
[71] Fig.5.29: "Update of the "MeetingTrack" data structure, based on [Lucas, 2010]" (p. 141).
[72] See Table 5.24: "The MeetingTrack event data structure of each agent" (p. 138).

The ABM version made available to the MFI stakeholders and policy-makers included an option to either visualise results in plots or write all details of every event between group participants into a comma-separated value (henceforth CSV) text file.

Property	**Description**	**Range**
plots	whether plots should be updated at runtime	boolean
iterations	number of times the model should run	1 to 10.000
init	set chosen configurations for running the model	clickable once
go	execute model according to Iterations and Init	clickable once

Table 5.22: Configurable parameters for running experiments using the EDSM

Table 5.23 below depicts the most influential parameters that influence results obtained in the EDSM. The selection of those affected by items three to five is random, as the occasional missing of meetings and –sometimes too– payments due to their individual conditions.

Item	**Property**	**Description**	**Range**
1	rural	whether is a rural or urban group	boolean
2	MFI-Group	size of the simulated group	3 to 7
3	bad investors	how many may invest badly	0 to 6
4	unprofitable	how many may be unprofitable	0 to 6
5	disease incidence	percentage subject to disease[a]	0% to 90%

[a] Of both clients and meetings that can be affected, rounded to the nearest number.

Table 5.23: Configurable parameters for group circumstances in the EDSM

Along with all items of the individual agent data structure "MeetingTrack" (listed on Table 5.24 on the next page), the following other elements are found in each agent internal variables: individual "TotalDebt", individual "Quota", a vector listing each of their "SpokenLanguages"[73], "Location"[74], "BusinessActivity"[75] plus a randomly assigned "Tolerance" between every participant to allow greater variation of results.

[73] If rural a language of Mayan ancestry is chosen and, if urban, Spanish is added too according to the list in Appendix VI: the Agent-Based Model (10th page from 206).

[74] Chosen from a list in Appendix VI: the Agent-Based Model (10th page from 206).

[75] Chosen from the set of possible urban or rural businesses sourced from the MFI. These are listed in the Appendix VI: the Agent-Based Model (11th and 12th pages from 206).

#	**Tracking**	**Description of the stored data**
0	the meeting	identification of the group meeting
1	the analysed client	identification of who is being analysed
2	the analyser client	identification of who is analysing
3	has the meeting been missed?	boolean about the analysed client
4	has the meeting been missed?	boolean about the analysed client
5	if a client is ill?	boolean about the analysed client
6	if a client is a bad investor?	boolean regarding the analysed client
7	the consequence	text description of the relevant event
8	the potential group loss	descriptive text about it
9	the client endorsement	acceptable, unacceptable or MyCondition[a]
10	the debt	the amount for this entry
11	the event's occurrence order	the order in the agent's registry

[a] The last type of event, MyCondition indicates an agent describing itself.

Table 5.24: The MeetingTrack event data structure of each agent

All agent properties, apart from the update-able components of the "MeetingTrack" vector, are immutable at runtime. If the simulation is configured with longer credit cycles ("Repayments", Table 5.25) and bigger groups ("MFI-Group", Table 5.23) invariably the number of entries in "MeetingTrack" will increase. This may lead to lengthier micro-level narratives of each simulated group, which allows a fine grained analysis of the complete history of events registered amongst members of the simulated group.

Table 5.25 on the next page depicts the configurable financial aspects of the EDSM. Despite suggestions that credit clients may change behaviour depending on their circumstances in relation to someone else is credit or debt values[76], the ABM that has been tested by stakeholders and policy-makers did not take these conjectures into consideration. There is no evidence, either from the MFI databases, administered data collection, interviewed credit officers or clients, that could backup an assumption of how the aforementioned economical aspects could influence behaviour. Thus, by following the evidence-driven approach from the EDTM, these financial properties are annotated in the "MeetingTrack" data structure (Table 5.24) for interpretation purposes, but do not influence how clients may endorse each other (Figure 5.29) in the simulation runs.

[76] See e.g. the first paragraph on page 125, regarding successful entrepreneur clients encountering difficulty in finding others with similar credit –or debt– to carry on within the MFI.

Property	Description	Range
interest rate	regarding the total individual debt	0.5% to 3%
equal credit	whether credit is equally divided	boolean
max agent debt	maximum amount of individual debt	$1.000 to $40.000
min agent debt	minimum amount of individual debt	$1.000 to $40.000
repayments	number of meetings at a credit centre	12 or 24 months

Table 5.25: Configurable financial parameters in the EDSM

The total range of relevant properties[77] includes a MFI -Group containing between three and seven people, assigned with 12 or 24 payments, either rural or urban, having disease incidence varying in decimal intervals from 0 to 100%, plus a number of unprofitable clients and bad investors varying from zero to seven. There are respectively 5, 2, 2, 7, 7 and 11 possible variations per parameter. Without considering the financial parameters, this amounts to 10.780 possible combinations to fully test the model parameter combinations. Sweeping through it all is unnecessary, as some combinations are either unrealistic or impossible. For example, both surveyed and interviewed stakeholders informed that groups with every participant being seriously ill, affected by unprofitability or bad investments would definitely not be granted credit. Thus such ABM combination does not need to be tested and it is also not addressed at all in the EDTM.

Given the aforementioned circumstances and the development approach discussed in Section 4.3: "Evidence-Driven Approach to Modelling (EDAM)" (page 86), the developed simulation does not allow setting all group members as being affected by an issue listed in Table 5.23: "Configurable parameters for group circumstances in the EDSM" (page 137). Nevertheless the simulation model could be easily adapted to test groups with all participants facing some type of adversity. Results could then be compared with those in Section 5.4.1: "Discussion of the EDSM Results" (page 147). The next pages of this section are dedicated to discuss how the ABM simulation and agents, which represent MFI clients, have been implemented.

[77] See Table 5.22: "Configurable parameters for running experiments using the EDSM", Table 5.23: "Configurable parameters for group circumstances in the EDSM" on page 137 and Table 5.25: "Configurable financial parameters in the EDSM" above.

The order in which the model is initialised is depicted in Figure 5.27 below. It starts with setting the basic configurations chosen by the user and internal properties, such as fixing the random seed plus making available all possible features (languages, business type and location) that clients will require for executing a simulation run.

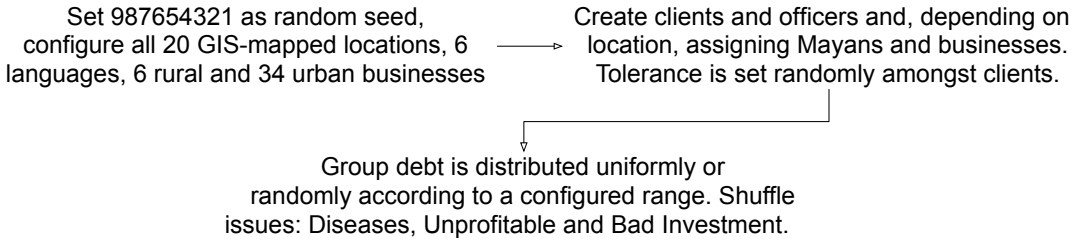


Figure 5.27: The initialisation processes of the EDSM

Once the model has been started with the configured initial conditions, the simulation will execute the procedures shown in Figure 5.28 below and Figure 5.29 (next page). According to settings described in Table 5.23 (page 137), the processing order of the top three issues hindering quota repayments (illness, bad investment and unprofitability) is shuffled[78] to avoid path-dependency (lock-in) issues. If events between simulated clients would have always been processed in the same order, results may have been influenced by the static nature (sameness) of such computational iteration. That is, if the simulation model reinforces itself to follow a certain computational path, changing this dynamics –and thus reach different results– may be intricate due to the attenuation (self-reinforcement) of positive or negative feedback from past choices. The fact that social conventions may emerge from repeated behaviour[79] does not mean that a modeller should hard-code these features. Doing so would simply demonstrate how one can, computationally, replicate such features and would thus not consist of a platform in which one may further explore the phenomenon of interest. Thus the proposed EDTM is inflicted with the issues, as depicted in Figure 5.28 on the next page, in a different order every time an experiment is run in the implemented ABM.

[78] I.e. each of the 6 combinations is proportionally distributed as about 16% of all events.
[79] Either self-organised, or constrained by an institution, as in the case of credit clients.

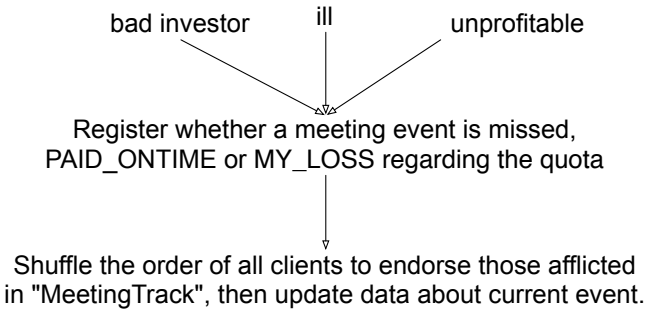


Figure 5.28: How issues afflicting clients are processed in the EDSM [a]

[a] Codes in capital letters denote internal events recorded by the model.

Figure 5.29 below describes how the EDSM proceed after reaching the last step shown on the previous figure. First all simulated clients, from the same group, are gathered into a vector that orders them differently every time an event should be processed. From this auxiliary data structure, yet another unordered list is created containing only those clients in adversity. In case there are defaulting events, all clients analyse the defaulter's circumstances in relation to one's own situation and then an event is registered in the corresponding individual "MeetingTrack" (Figure 5.24, on page 138).

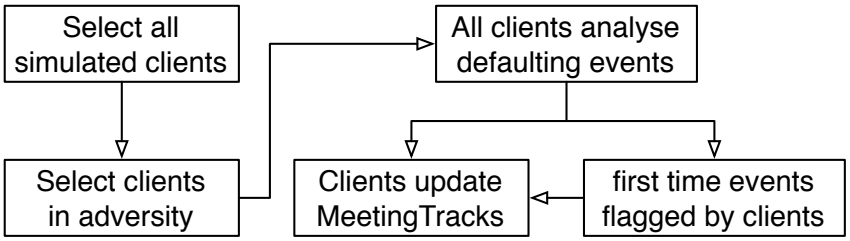


Figure 5.29: Update of the "MeetingTrack" data structure, based on [Lucas, 2010]

Events occurring for the first time are flagged individually as, e.g. one would not consider expelling someone who missed a meeting or payment just once[80]. Events are processed sequentially but the order in which agents join this queue is never the same, which is yet another mechanism to avoid computational path-dependency issues that agents could otherwise reinforce at runtime.

[80] See findings discussed based on Table 5.13: "According to officers, what clients do when a meeting is missed?, Table 5.14: "According to officers, what clients do when a payment is missed? and Figure 5.24: "A schematic representation of the clients' decision-making" (pages 113, 129).

Once all agents –including defaulters– assessed the circumstances and registered each event regarding other agents in the current meeting, the remaining round of evaluations ("Meeting") are sequentially processed following again what is depicted in Figure 5.28: "How issues afflicting clients are processed in the EDSM" (page 141). Then the quota cycle depicted in the figure above continues to be processed. Table 5.26: "Summary of all possible events in the "MeetingTrack"" on the next page contains the description and summary of all possible events during a simulation that can be recorded. Obviously there are more events regarding other group participants than oneself in this data structure. The top three listed in it (MyStatus, MyLoss and PaidOnTime) are those used by agents to describe their own circumstances during a particular meeting.

The events listed in the first column appear in the 9th slot of the data structure depicted in Figure 5.24: "The MeetingTrack event data structure of each agent" (page 138). Occasionally this text description will also appear in the 7th slot, named Consequence, of the same vector data structure to facilitate the reading of obtained simulation results. All other listed events are the result of one agent analysing the other. These updates are processed recursively until the number of configured simulated meetings is reached. Unsurprisingly this process can sometimes generate a substantially long text log. That is due to the number of individual entries tending to increase as a direct proportion to the number of defaulting –or missed meeting– events.

The narrative as to how surveyed stakeholders use their social conventions was constructed based on the EDTM, is depicted in Figure 5.23: "The proposed EDTM of decision-making within MFI groups (page 128) and validated with interviews by the randomly selected stakeholders as a good approximation to what happens in their reality. There may be slight, or perhaps even significant, variations of this elsewhere within the MFI is geographical area of operation, but the discussed ABM is inline with the cross-sectional findings discussed in the first two sections of this chapter.

Event	Requisite	Description	Consequence
MyStatus	assess oneself	one's own situation	none directly
MyLoss	assess oneself	one's own default	none directly
PaidOnTime	assess oneself	acknowledgement	none directly
LeaderVisit	assess adversity [a]	social pressure [b]	NoLoss [c]
GroupVisit	assess adversity [d]	social pressure [e]	NoLoss [f]
Support	assess adversity [g]	cooperation intent [h]	CoveredLoss [i]
Fine	assess adversity [j]	cooperation intent [k]	Fine [l]
CoverLoss	assess adversity [m]	vote for covering loss	NoLoss [n]

[a] I.e., assess circumstances of who missed –for the first time– a meeting but not a payment.
[b] I.e., apply the first instance of social pressure according to fieldwork findings (see Figure 5.24: "A schematic representation of the clients' decision-making", page 129).
[c] I.e., if tolerant this social sanction is deemed as acceptable, otherwise as unacceptable.
[d] I.e., assess someone subjected to a LeaderVisit but who has not yet missed a payment.
[e] I.e., this is the second, or next, instance of social sanctions mentioned in footnote *b*.
[f] I.e., if tolerant this is deemed by the client as acceptable, otherwise as unacceptable.
[g] I.e., assess who has missed at least one meeting and payment during the credit history.
[h] See Table 5.6 "Supportive actions witnessed in microcredit groups" (p. 105) and 5.8: "Actions within groups supported by participants' morality and ethics" (p. 107).
[i] I.e., if the client is ill and the analyser is tolerant to that, register it as acceptable.
[j] I.e., assess someone who has missed at least one meeting or payment in past meetings.
[k] Also based on footnote *h*, but additionally cast a vote for a further sanction.
[l] I.e., registered as unacceptable if healthy, otherwise cast a vote for a MFI _Fine.
[m] I.e., assess a known defaulter who has at least covered once someone's previous loss.
[n] I.e., register as acceptable if evaluator is tolerant to the subject, otherwise unacceptable.

Table 5.26: Summary of all possible events in the "MeetingTrack"

The use of a data-driven development lifecycle[81] helps to systematically gather and justify which evidence (i.e. quantitative and/or qualitative data) to guide the building of the model discussed in this section. This is helpful as the modeller can bear in mind which evidence (experimental or not) is principled as it has been systematically collected and validated based on a quantitative and/or qualitative behavioural methodology. In this research thesis, such guidance has come from carrying out the adapted EDTM[82].

Note that each of the three adversities affecting clients, listed in Table 5.23: "Configurable parameters for group circumstances in the EDSM" (page 137), could be subject to entirely new research projects. Due to their ample influence potential, these have been simplified as tags in agents to represent who is afflicted by a conditions and who triggers event entries from other agents in case of missed meetings and/or payments.

[81] See Section 4.3: "Evidence-Driven Approach to Modelling (EDAM)" (page 86).
[82] See Figure 4.17: "The adapted EDTM development cycle" (page 93).

Figure 5.30 is a top-level view of the ABM algorithm[83]. The structure is described to facilitate the model understanding. It should be read with support of Table 5.26: "Summary of all possible events in the "MeetingTrack"" (page 143), Table 5.6: "Supportive actions witnessed in microcredit groups" (page 105) and also Figure 5.23: "The proposed EDTM of decision-making within MFI groups" (page 128).

```
Set all control variables to 0 and random seed to 987654321
Load all possible languages, locations, urban and rural businesses
Configure group with debts, adversities, tolerances and above attributes
Write all configured parameters in the simulation output text file
Set timer to 0 and OrderOfTrackedEvents with CurrentOrder as 1.1

REPEAT
        shuffle ProcessingOrderOfAdversities in the current meeting

        Set number of meetings that may be subject to DiseaseIncidencePercentage
        Randomly set who will be sick, also based on DiseaseIncidencePercentage
        Randomly set who may be subject to unprofitability or a bad investment
        Set ListOfAgentsInAdversity, uniquely identifying each of the affected agents

        WHILE there are still outstanding quotas to be paid and active meetings to attend

                Randomly set whether someone in ListOfAgentsInAdversity missed the meeting
                Randomly set whether those added to ListOfAbsentAgents missed a payment
                Log  data in OrderOfTrackedEvents, each entry with CurrentOrder + 0.1

                REPEAT

                        FOR_EACH agent entry in the ListOfAgentsInAdversity
                            Search data about each agent in other agent's OrderOfTrackedEvents
                            Deal with missed meetings and payments
                        END_FOR

                UNTIL processing the given fixed order, per meeting, of all simulated group members

        END_WHILE

        WRITE in the simulation output text file

                total number of Acceptable and Unacceptable events
                the complete OrderOfTrackedEvents history of all agents

                SUMMARISE total number of events
                END_SUMMARISE

        END_WRITE

    Set all control variables to 0 and TotalNumberOfSimulationRuns + 1
UNTIL reaching TotalNumberOfSimulationRuns
```

Figure 5.30: Pseudo-algorithm of the implemented EDSM

[83] Included in "Appendix VI: the Agent-Based Model" (page 206).

5.4 Insights Based on the ABM analysis

The insights provided by the implemented ABM, which has been developed based on the data collected using the lifecycle described in Chapter 4: "Research Design and Development" (page 75) and discussed in the previous sections, in this thesis are two-fold. Firstly, the ABM generates a micro-level record in each simulation run by providing:

- (I) a sequential log of registered events between microcredit clients in their group;
- and (II) a textual description of the same data, presented as a short story.

Examples of these can be found on pages 148 and 149, where Table 5.27: "Micro-level log example (1 unprofitable, no missed payment)" and Table 5.28: "Micro-level log example (unprofitable default, missed meeting)" are respectively discussed in detail.

Another type of insight provided by the ABM is the ability to systematically analyse macro level patterns of simulated microcredit groups. These are obtained by varying a range of feasible group configurations and circumstances, to observe the impact on groups ranging from their minimum size up to the maximum number of seven[84]. The analyses based on the macro-level patterns have been focused on the frequency of the overall number of observed events between clients in simulated microcredit groups:

- there are few differences between simulated groups configured with 1 or 2 unprofitable clients, 1 unprofitable and 1 bad investor, or disease incidence affecting a group at 20%, 30% or 60% levels (results are discussed on pages 152 and 154);
- similar results are obtained by simulating groups configured with 3 or 4 unprofitable clients, 3 unprofitable clients plus 1 bad investor and 2 unprofitable plus 2 bad investors (results are discussed in greater detail on pages 157 and 156);

[84] See Figure 5.19: "Distribution of group size amongst surveyed clients" (page 121).

- another set of similar results are presented regarding simulated groups with disease incidence configured at 40%, 80% and 90% levels (discussion on page 158);

- other different patterns are discussed regarding groups containing 5 unprofitable clients (see page 159) and those with 10% of disease incidence (see page 160);

Discussing findings, both obtained in fieldwork and the ABM, with stakeholders was key to ascertain the relevance of insights to the regulatory framework of the MFI. The expert stakeholders reported greater confidence in using the simulation to analyse the systematic dynamics of configured microcredit groups because the agent-based model was developed based on the data collected directly from their clients[85]. The reported stakeholder experience of participating in the EDTM[86] modelling process is also considered important by the author –and this has also been highlighted by the MFI stakeholders– as a way to facilitate the understanding of how conventional social behaviour amongst clients can influence a policy long-term success. Without this, seemingly unimportant aspects about the social phenomenon could have been overseen, and thus disregarded when formulating assumptions to be implemented in an ABM.

Qualitatively validating ABM results that have no comparable quantitative evidence is an eminent issue, and this seems only clarified by comparing quantitative simulation results with new quantitative data. There has been methodological progress, yet reliability of validation procedures is incipient. This contributes to ABM research being, to date, discussed rather more in theoretical and technical terms than practical applications [Boero and Squazzoni, 2005, Bankes, 2002, Edmonds et al., 2013]. Whilst interpreting the models' processes and outputs can improve ones' understanding of the simulations, practical relevance of new findings to policy-making depend on analysis of empirical evidence. The developed ABM contributes with results that complement these with insights that would be otherwise unattainable without such a simulation.

[85] In a process that the stakeholders themselves participated, thus were familiar with.
[86] See Figure 4.17: "The adapted EDTM development cycle" (page 93).

5.4.1 Discussion of the EDSM Results

In total 41 different configurations were tested to provide data for the sensitivity analysis of the implemented ABM. Stakeholders considered credible both the modelling approach and obtained results, which is good feedback from applying the lifecycle described in Section 4.3: "Evidence-Driven Approach to Modelling (EDAM)" (page 86). Each configuration has been simulated 10.000 times[87] and results were logged in detailed comma-separated value[88] (CSV[89]) files containing all the computed data per agent (i.e. the micro-level of what occurs in a simulated group) and across agents (i.e. the macro-level properties regarding all runs).

The hardware used to simulate the experiments was: an Intel Core 2 Duo at 2.26 GHz, 3MB L2 cache, bus speed at 1.07 GHz and 8 GB of RAM, running the "testing" version of Debian Linux. The fastest simulation ran in about 0.16 seconds, whilst the longest took about 4357.82 seconds, with an average of 8.16 seconds and a standard deviation of 23.77 seconds. The simulation model requires little computing power, despite the intricate data structures and processes described in the previous chapter (Section 5.3.3: "Structure, Processes and Parameters of the EDSM", page 136).

The aforementioned aspect would, however, not be the case if one the three adversities (illness, unprofitability and bad investments) were modelled with greater complexity than the simple stochastic and probabilistic nature in this version (see discussion of Figure 5.28: "How issues afflicting clients are processed in the EDSM"', page 141).

[87] Due to the sheer number of runs, it was needed to increase the Java heap size (using "Xmx7GB") to run all simulations, so the virtual machine would not run out of memory.

[88] I.e., a simple database file where each line is a record and fields are separated by commas.

[89] All CSV files were processed using shell scripts, which contained pipes ("|") connecting serialised results obtained from running scripts using the following tools[90]: "grep, awk, tail, xargs, find, echo, print, sort, exit, uniq" along with output/input redirectors "<, <<, >, >>".

As an example, Table 5.27 below depicts all micro activity of a simulated group: individual events logged for the simulation run number 95. Through 12 meetings, the simulated microfinance group generated a database with 14 entries. Only those in bold describe what the group did regarding the event of interest, which is client_0 having missed a meeting. This group of urban clients, located in Ixtapa, was configured with three businesses: Grocery Store, Piñata[91], Ice Cream Seller. Their languages consisted of: all knowing Spanish, plus two knowing Tsotsil and one knowing Tojolabal. The complete parameters list is discussed in greater detail in Section 5.3.3: "Structure, Processes and Parameters of the EDSM" (page 137).

#	Target	From	Missed	Event	Quota	Status
1	client_0	client_0	false	MyStatus	OnTime	MyStatus
2	client_0	client_0	false	MyStatus	OnTime	MyStatus
3	client_0	client_0	false	MyStatus	OnTime	MyStatus
4	client_0	client_0	false	MyStatus	OnTime	MyStatus
5	client_0	client_0	false	MyStatus	OnTime	MyStatus
6	client_0	client_0	false	MyStatus	OnTime	MyStatus
7	client_0	client_0	false	MyStatus	OnTime	MyStatus
8	client_0	client_0	false	MyStatus	OnTime	MyStatus
9	client_0	client_0	false	MyStatus	OnTime	MyStatus
10	client_0	client_0	false	MyStatus	OnTime	MyStatus
11	**client_0**	**client_0**	**true**	**MyStatus**	**OnTime**	**MyStatus**
11	**client_0**	**client_1**	**true**	**LeaderVisit**	**NoLoss**	**Unacceptable**
11	**client_0**	**client_2**	**true**	**LeaderVisit**	**NoLoss**	**Acceptable**
12	client_0	client_0	false	MyStatus	OnTime	MyStatus

Table 5.27: Micro-level log example (1 unprofitable, no missed payment)[abc]

[a] MyStatus allows one to identify which client is adversely affected (client_0 in this case).
[b] The first column indicates which of the 12 meetings, each due N$156, the entry is about.
[c] The third column indicates whether a meeting has been missed.

The verbatim output from the simulation model is equivalent to reading the following: *"A group with 3 is located in Ixtapa with the following individual businesses: grocery, piñata and ice cream. They had a 12-quota credit and 1 participant that is being unprofitable, which lead to missing only the 11th meeting, without incurring a loss. That occasion was deemed as acceptable by one member and unacceptable by another."*

[91] I.e., a *papier mâché* figure containing toys and candy for children to celebrate festivities.

Thus the more missed meetings and payments, the longer the story to tell will be. That is in turn influenced by the group size, how many quotas must be processed and how many are affected by an adversity. In this case, tolerance differentiated "Status"[92]. Table 5.28 is a different example to that one presented on the previous page, as now an unprofitable client misses both a meeting and payment. This simulation (run number 146) was configured with 12 quotas and group size 3. This case presents three events to be endorsed, so the log length increased to 18. Up to the 5th meeting, then again at the 10th meeting, events are registered as those previously presented. Nevertheless, the 12th meeting presents a default by client_0, which is willingly covered by client_1 but unwillingly (due to the occurrence of VoteExpel) by client_2. This group was located in Larrainzar, having three languages (Mam, Zoque and Spanish) with three different businesses (hammocks, clothing and fishery).

#	Target	From	MM	MP	Event	Quota	Status
1	client_0	client_0	false	false	MyStatus	OnTime	MyStatus
2	client_0	client_0	false	false	MyStatus	OnTime	MyStatus
3	client_0	client_0	false	false	MyStatus	OnTime	MyStatus
4	client_0	client_0	false	false	MyStatus	OnTime	MyStatus
5	**client_0**	**client_0**	**true**	**false**	**MyStatus**	**OnTime**	**MyStatus**
5	**client_0**	**client_1**	**true**	**false**	**LeaderV.**	**NoLoss**	**Acceptable**
5	**client_0**	**client_2**	**true**	**false**	**LeaderV.**	**NoLoss**	**Unacceptable**
6	client_0	client_0	false	false	MyStatus	OnTime	MyStatus
7	client_0	client_0	false	false	MyStatus	OnTime	MyStatus
8	client_0	client_0	false	false	MyStatus	OnTime	MyStatus
9	client_0	client_0	false	false	MyStatus	OnTime	MyStatus
10	**client_0**	**client_0**	**true**	**false**	**MyStatus**	**OnTime**	**MyStatus**
10	**client_0**	**client_2**	**true**	**false**	**GroupV.**	**NoLoss**	**Unacceptable**
10	**client_0**	**client_1**	**true**	**false**	**GroupV.**	**NoLoss**	**Acceptable**
11	client_0	client_0	false	false	MyStatus	OnTime	MyStatus
12	**client_0**	**client_0**	**true**	**true**	**MyStatus**	**MyLoss**	**MyStatus**
12	**client_0**	**client_1**	**true**	**true**	**CoverLoss**	**NoLoss**	**Acceptable**
12	**client_0**	**client_2**	**true**	**true**	**VoteExpel**	**AvoidL.**	**Unacceptable**

Table 5.28: Micro-level log example (unprofitable default, missed meeting)[abcde]

[a] MyStatus allows one to identify which client is adversely affected (client_0 in this case).
[b] The first column indicates which of the 12 meetings, each due N$136, the entry is about.
[c] The third column (MM) indicates whether a meeting has been missed.
[d] The forth column (MP) indicates whether a payment has been missed.
[e] LeaderVisit, GroupVisit and AvoidLoss were abbreviated due to diagrammatic limitations.

[92] Discussion in Section 5.3.2: "The Evidence-Driven Simulation Model (EDSM)" (page 132).

The story presented to stakeholders about events occurred in this group consisted of:

"A group with 3 is located in Larrainzar with the following individual businesses: hammocks, clothing and fishery. They had a 12-quota credit and 1 participant that is being unprofitable, which lead to missing 2 meetings (the 5th and 10th), without incurring a loss. These occasions were each deemed as acceptable by one member and unacceptable by another. There was a default by the unprofitable member at the last meeting. That was covered willingly by client_1 and unwillingly by client_2, who also casted an expel vote."

The previous two pages illustrate how the micro-level textual log of the EDSM unfolds during the simulation runs and how the stories were presented to the MFI stakeholders. Many thousands of these are the reason for the large size of the database with all simulation results. Figure 5.31 on the next page depicts how the total number of events varied across all configurations of the simulations. As one can notice, most simulation runs yield results closer to the lower end of the presented scale. If one takes into account all simulated experiments, relatively few simulation runs yielded totals that concentrate near the very minimum number of event entries. Similarly, the further away from the average (81), one can observe a decreasing trend on the total number of registered event entries.

One can also observe a rather large number of simulation runs registering total number of event entries between the outer area delineated by the 39.85 value and inner area delineated by the 123.4 value. Configurations that generated the lengthiest textual results[93] were the most difficult for stakeholders to interpret and the ones the MFI stakeholders found least useful –precisely due to the intricate story. It is worth noticing that this is in accordance with findings published elsewhere regarding how policy-makers are more likely to take into consideration shorter, more practical summaries [Jones et al., 2008].

[93] E.g., those configured with a large group affected by adversities and a 24 credit cycle.

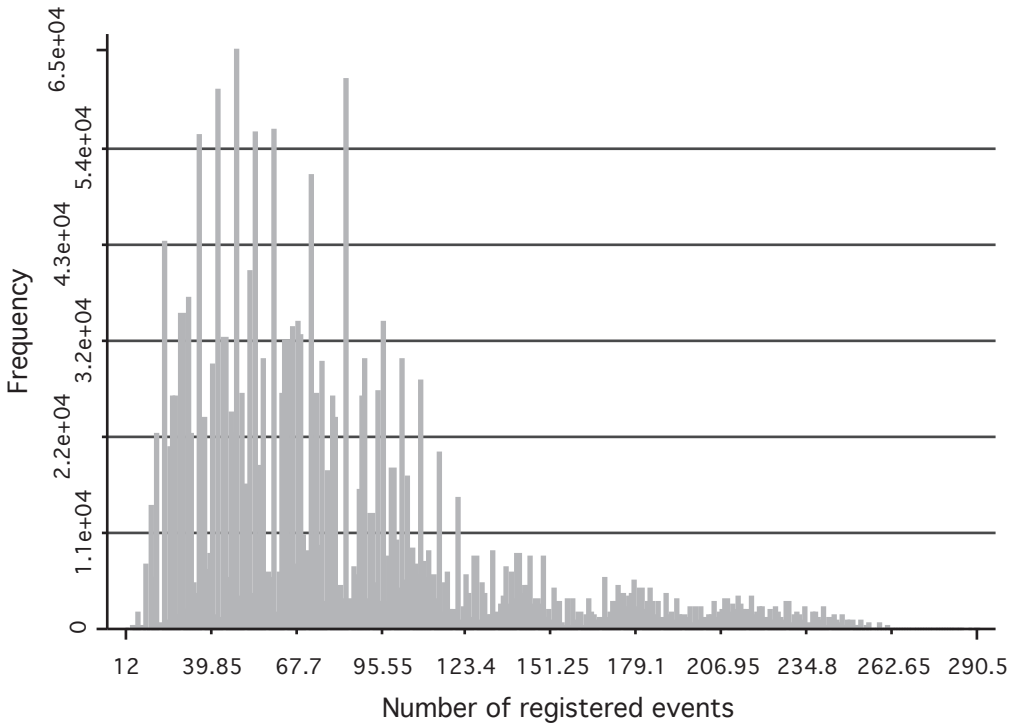


Figure 5.31: Total number of event entries between agents, across simulations

The aforementioned aspect, along with the need to further understand the dynamics of the simulation model itself, prompted the analysis of the macro-level properties yielded from groups of simulation experiments. Hence, from this paragraph until the end of this chapter, the discussion is dedicated to scrutinising the observed features in the aggregate dataset generated by running every plausible configuration allowed in the model. The MFI stakeholders found this a useful exercise in exploring scenarios based on their clients observed and reported behaviour.

Results from testing different configurations have been grouped by similarity regarding their macro-level properties of each run, and have been aggregated for the macro-level analysis. The previously discussed micro-level results are more detailed, as in it every single event in every simulated group is logged. In other words, that dataset contains every default and missed meeting along with the generated event entries from every group member. The minimum total number of micro-level entries is 12 registries, whilst the maximum was 291 registries. The average of all simulated experiments was 81 registered events and the standard deviation is of 50 registered events.

Figures 5.32 and 5.33 below depict, correspondingly, averages and standard deviations of the total number of representative events[94]. The data resulted from running simulations *ceteris paribus* with one unprofitable client, varying group size. Those configured with 12 quotas are depicted as (a), whilst (b) corresponds to simulation runs with 24 quotas. This notation is used throughout.

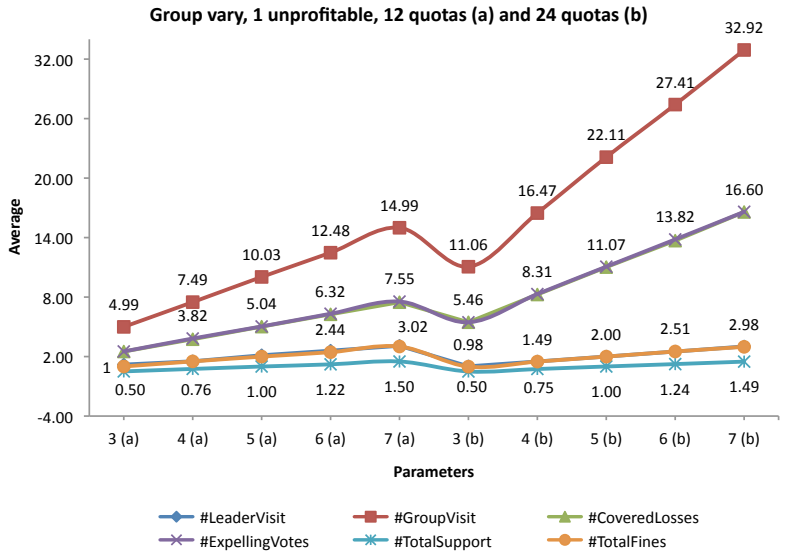


Figure 5.32: Average number of registered events (1 unprofitable)

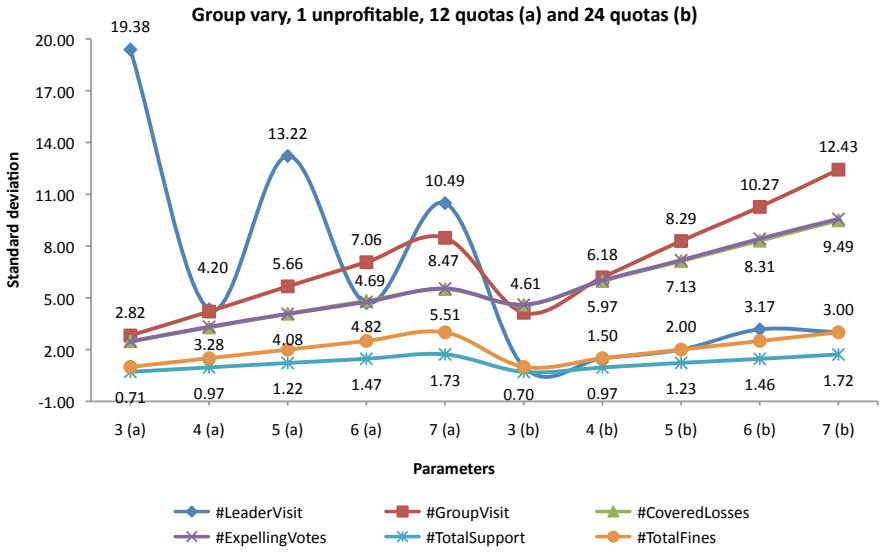


Figure 5.33: Standard deviation of registered events (1 unprofitable)

[94] I.e. LeaderVisit, GroupVisit, CoveredLosses, ExpellingVotes, TotalSupport, TotalFines.

Despite variations in how often certain events occur, GroupVisit is the predominant event in simulations depicted on the previous page and Figure 5.34. These include simulations where the group size varied with: 1 unprofitable, 2 unprofitable, 1 unprofitable plus 1 bad investor, 20%, 30% and 60% disease incidence. All plots, apart from the top left corner and middle left ones, depict CoveredLosses as more frequent than ExpellingVotes. The other events remain largely stable throughout the runs.

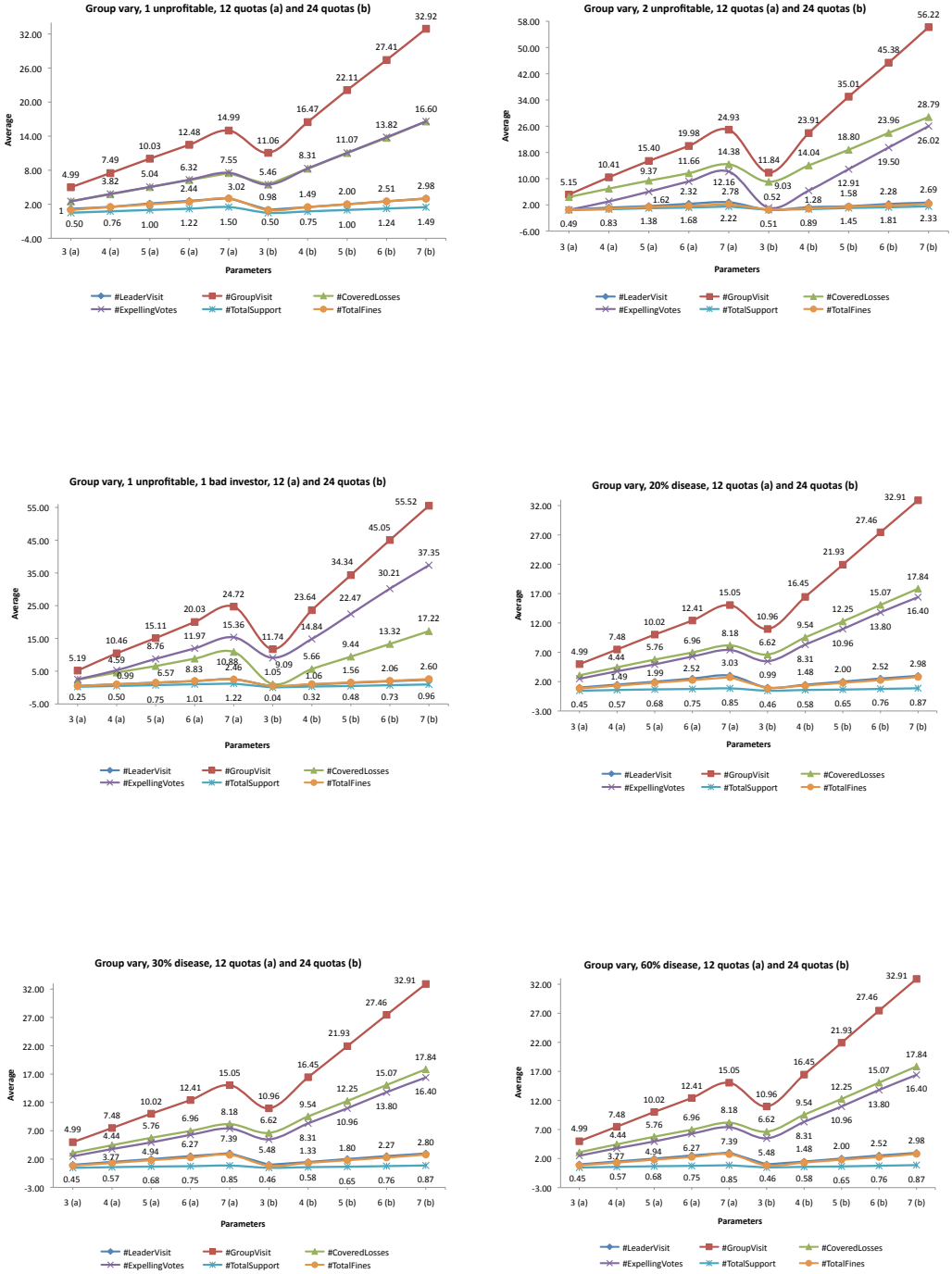


Figure 5.34: Simulation runs with averages similar to that of Figure 5.32

Most standard deviations in Figure 5.35 remain relatively proportional to each other,

apart from those corresponding to LeaderVisit. Results below and those shown in Figure 5.34 suggest that, under these 6 depicted conditions, large variations of LeaderVisit will not significantly influence the occurrence of GroupVisits and other events. This is counterintuitive, given that the latter can depend on the former to occur.

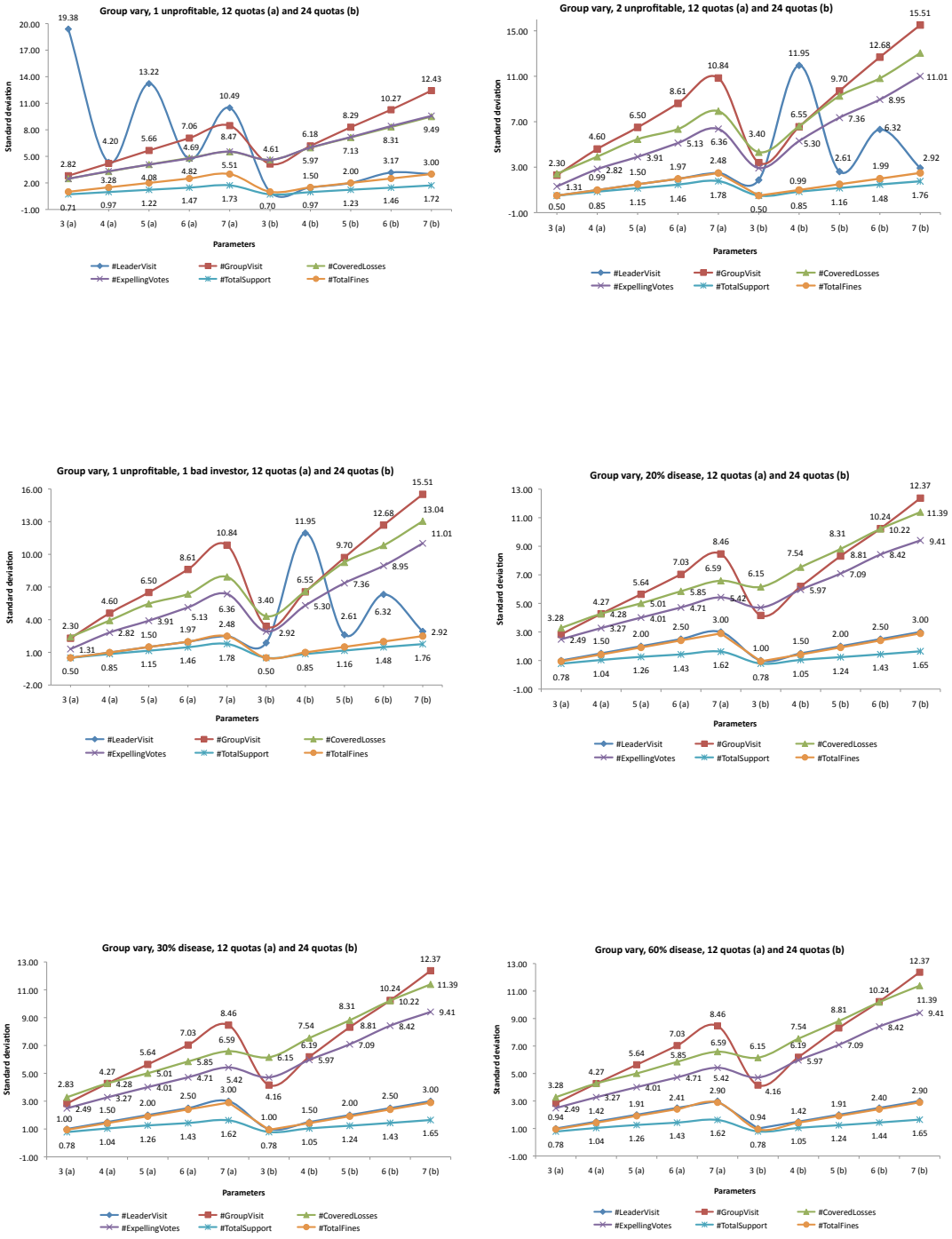


Figure 5.35: Simulation runs with standard deviations similar to Figure 5.33

Figure 5.36 shows that, again, GroupVisit is the most frequent event. That is despite the large variation of occurrences, as shown in Figure 5.37. Other relatively frequent events include ExpellingVotes and CoveredLosses. The remaining ones, TotalSupport and TotalFines, are expectedly shown as having little relevance in this context: these are rather generally infrequent due to the impact on groups[95].

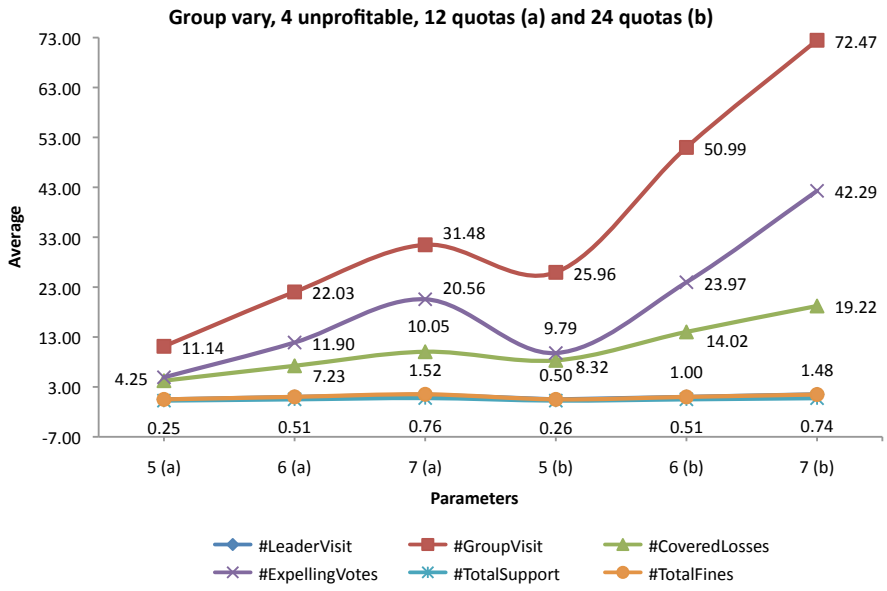


Figure 5.36: Average number of registered events (4 unprofitable)

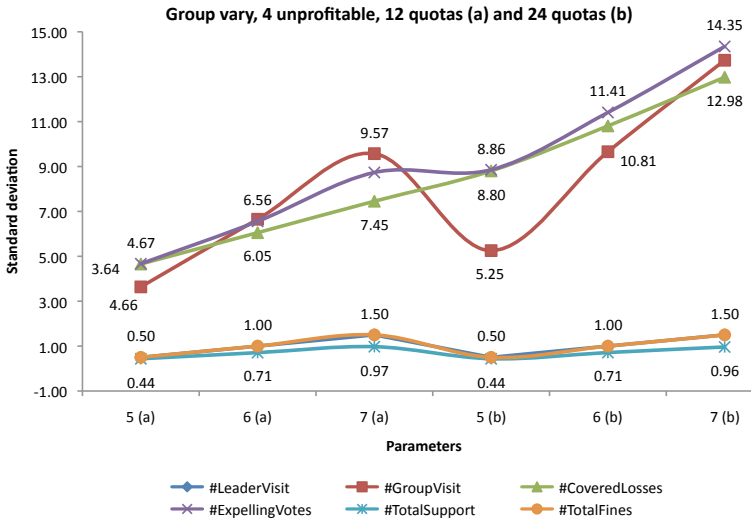


Figure 5.37: Standard deviation of registered events (4 unprofitable)

[95] See Table 5.14: "According to officers, what clients do when a payment is missed?", page 113).

In the case below, the observed macro-level pattern (seen first in Figure 5.32, on page 152) remains similar under all different configurations shown in Figure 5.34. These include runs where the group size vary with: 3 unprofitable, 4 unprofitable, 3 unprofitable plus 1 bad investor and 2 unprofitable plus 2 bad investors. Under such conditions one can say that the event dynamics between group members is essentially the same.

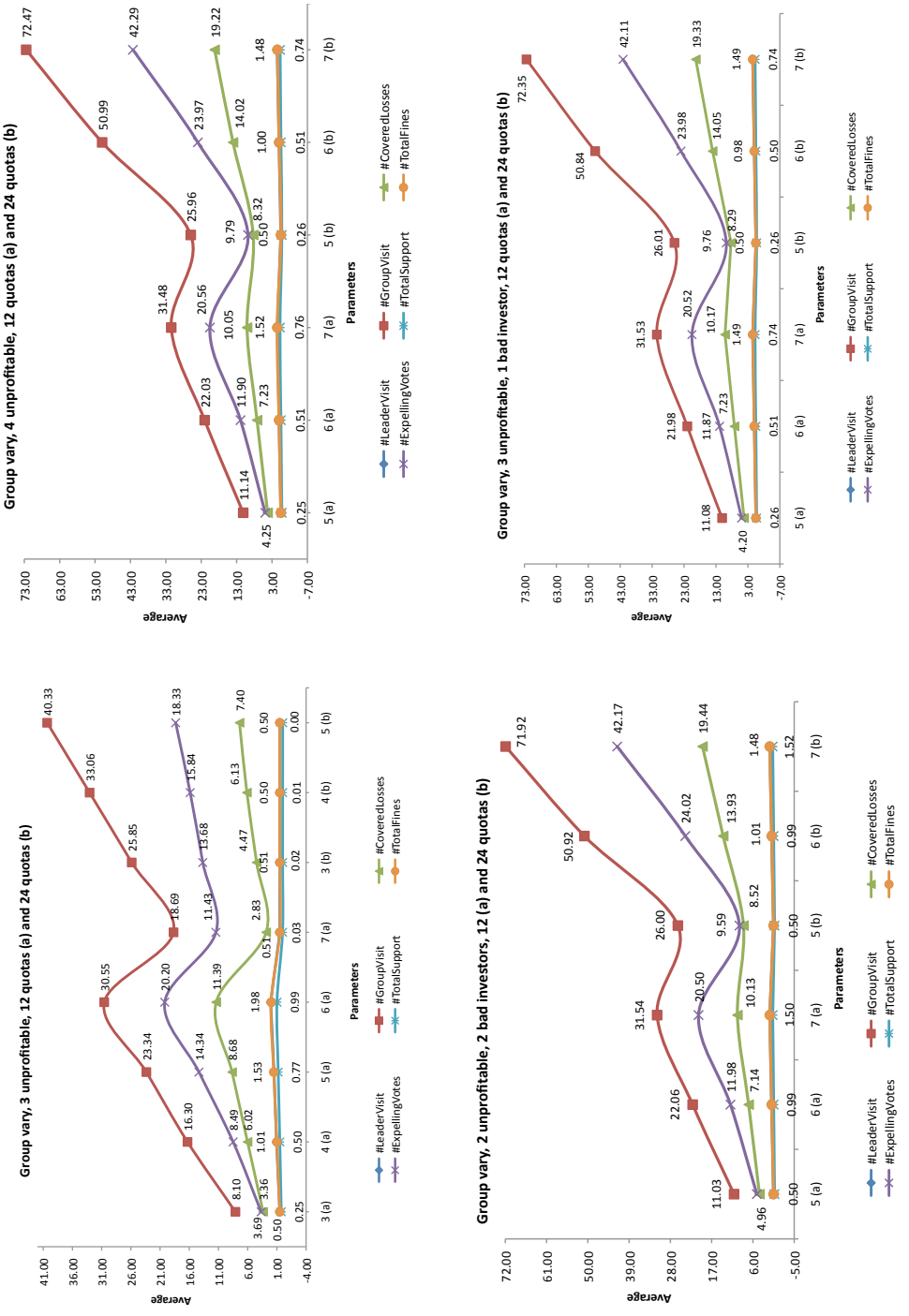


Figure 5.38: Simulation runs with averages similar to those of Figure 5.36

In Figure 5.39 below, it is possible to notice that only the graph in the bottom left corner displays considerable variance in the occurrence of LeaderVisit. This suggests that the overall pattern of total number of GroupVisit events being closely followed by ExpellingVotes and CoveredLosses, observed in Figure 5.36 on the previous page, is not dependant on such event. There are also differences in the occurrence of CoveredLosses, but that is not significant and also therefore not relevant for the analysed simulations.

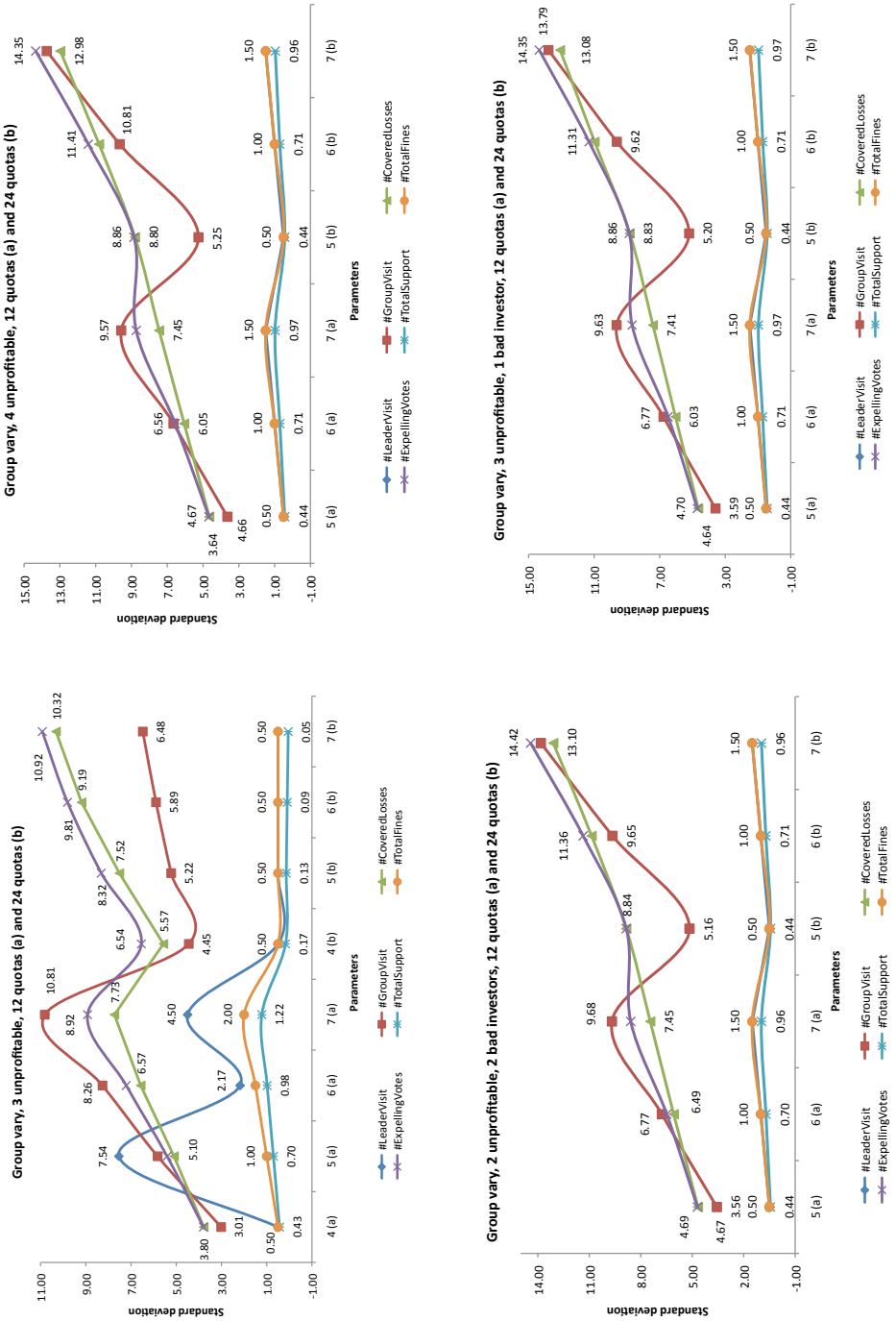


Figure 5.39: Simulation runs standard deviations similar to Figure 5.37

The next four graphs in Figure 5.40 depicts the similar average and standard deviations of running simulations, *ceteris paribus* varying only group size, with 40% and 80% of disease incidence. Simulation runs with 90% also lead to plots that are similar in kind as those shown below. With 12 quotas, i.e. circumstance (a), one can see the ABM leading to similar frequency of CoveredLosses and ExpellingVotes. Yet 24 quotas, i.e. circumstance (b), the difference increased unexpectedly, as then the frequency of CoveredLosses outgrows ExpellingVotes –implying a different social dynamics in groups.

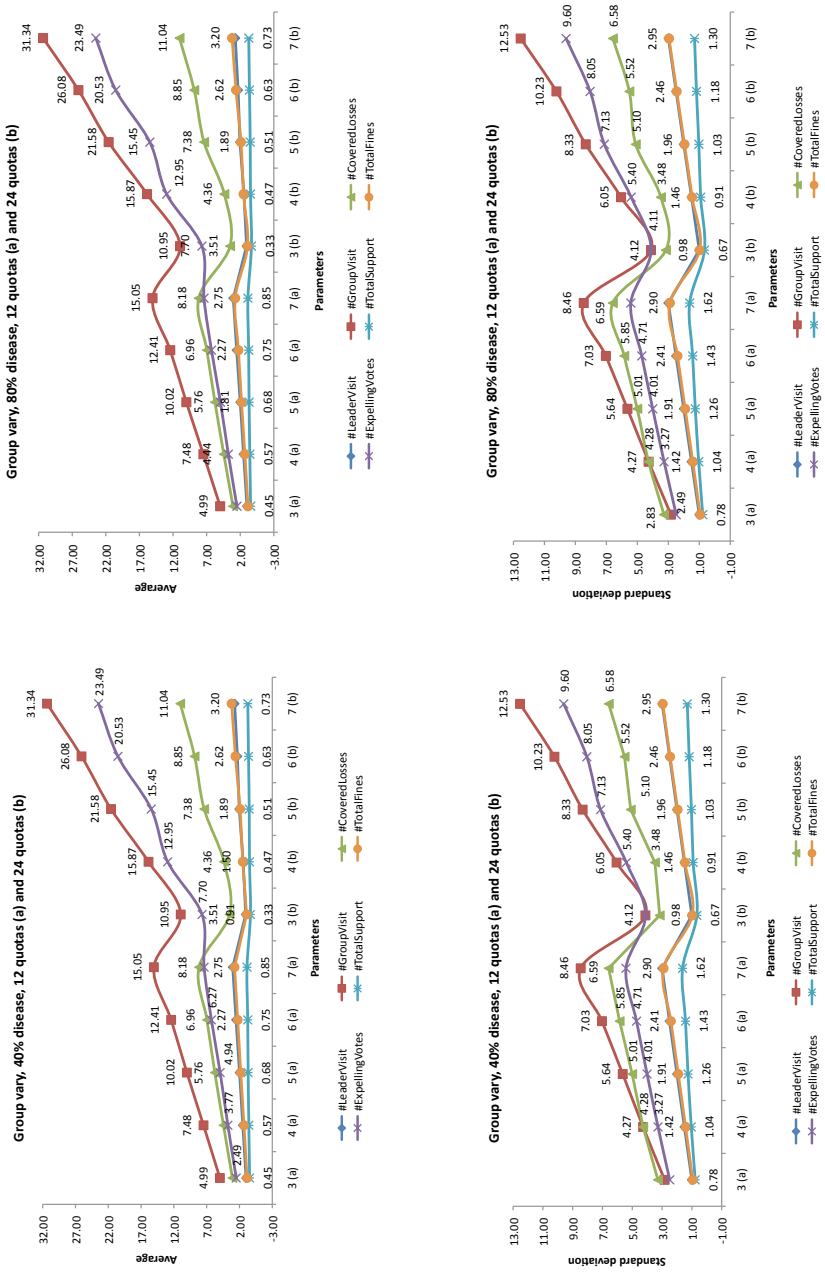


Figure 5.40: Averages and standard deviations (40% and 80% disease)

Figure 5.41 and 5.42 below depicts similar results to the simulation runs containing 5 unprofitable with 12 quotas (Figures 5.38 and 5.39, pages 156 and 157 respectively). However under the same circumstances and having to deal with 24 quotas, there is a sharp decrease in the actual frequency and standard deviation of observed events. This is unexpected result, as there is an increase in the total number of registered events.

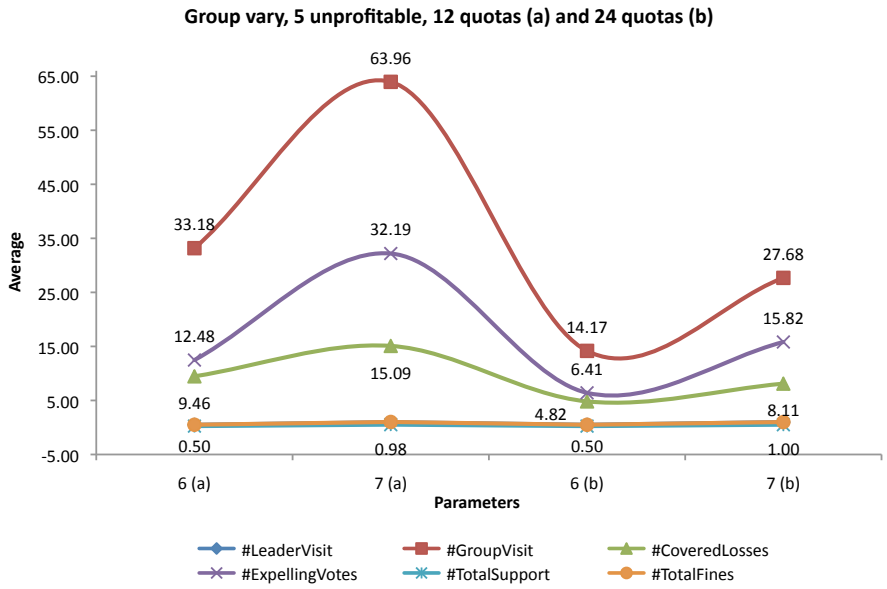


Figure 5.41: Average number of registered events (5 unprofitable)

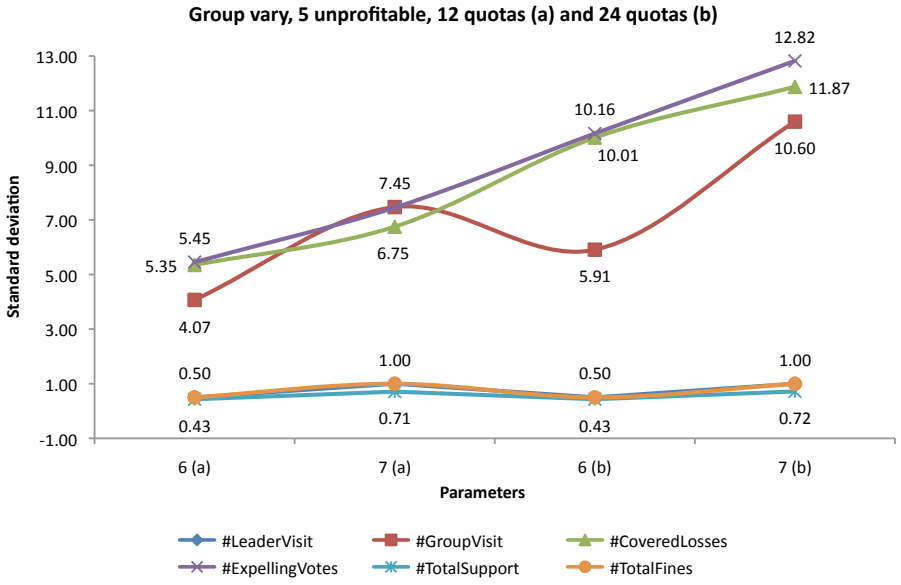


Figure 5.42: Standard deviation of registered events (5 unprofitable)

On the other hand, Figure 5.43 below depicts the only observed configuration in which the average frequency of events in fact decreases when the number of participants and quotas are increased. This is also the only result that other events, namely CoveredLosses and ExpellingVotes, in which the standard deviation eventually surpasses GroupVisit (as shown in Figure 5.44). I.e. the standard deviation of the aforementioned events are not higher than the latter from the onset of (b) data.

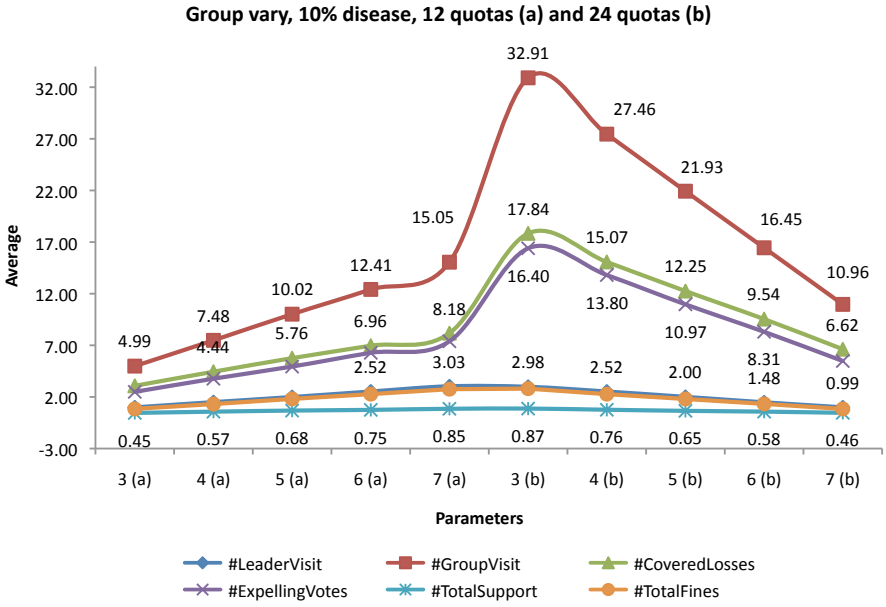


Figure 5.43: Average number of registered events (10% disease incidence)

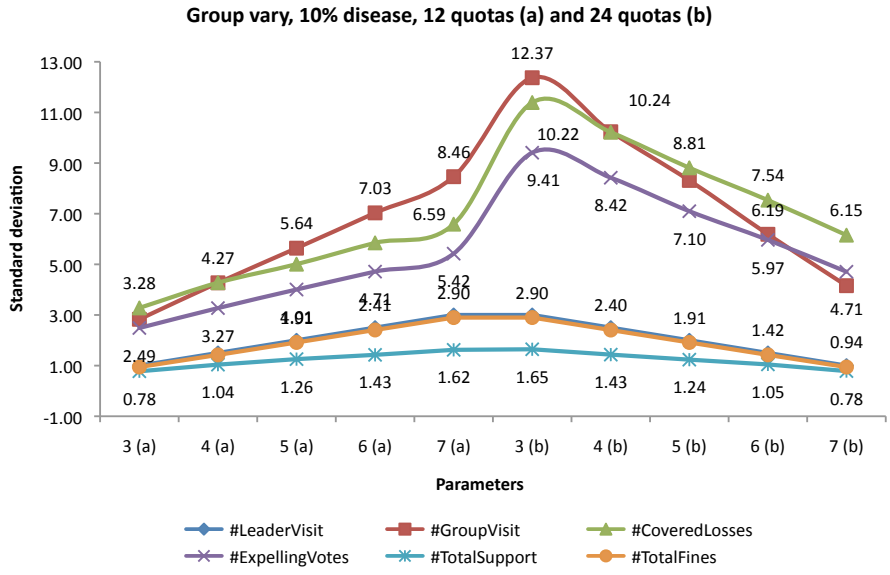


Figure 5.44: Standard deviation of registered events (10% disease)

Figure 5.45 below depicts the overall dynamics of groups having all but one participant being affected with an adversity. Surprisingly there was, in average, more GroupVisits and ExpellingVotes with 12 quotas, instead of 24, in simulations with 6 unprofitable participants (bottom left) –despite the relatively high standard deviations. In runs configured with 3 unprofitable and 3 bad investors with 24 quotas, GroupVisit surpassed all other events put together. Another unexpected result is that all least frequent events remained within narrow boundaries in all of the simulations shown below.

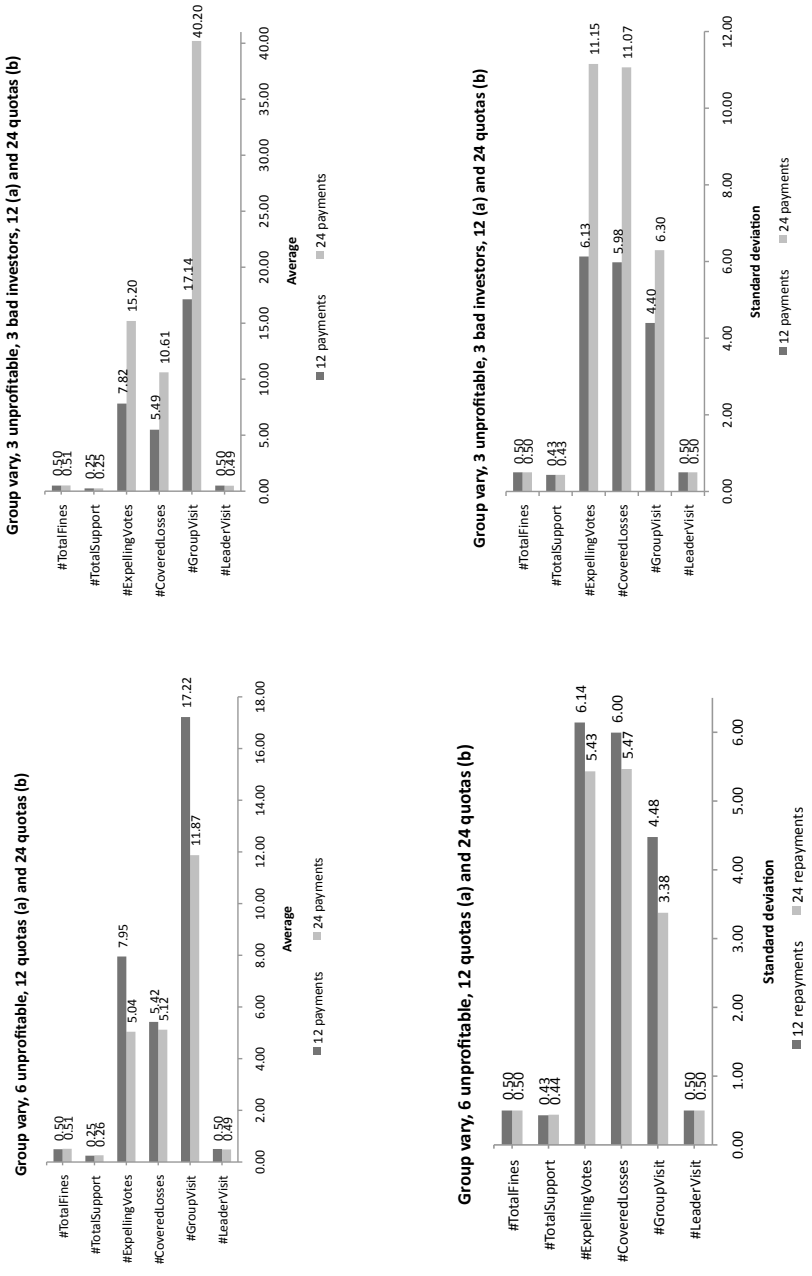


Figure 5.45: Averages and standard deviations (6/3 unprofitable, 3 bad investors)

The Figures below show the total number (173) of randomly drawn simulation configurations. Figure 5.46 depict the aggregate, and corresponding percentile, number of simulations that ended with a full credit cycle with either more acceptable or unacceptable endorsed events. One can notice that there is a somewhat similar shape –with unexpectedly significant percentiles– about how simulations, with microcredit groups ranging from 3 to 7 members, tend to endorse each other until the end of a simulation.

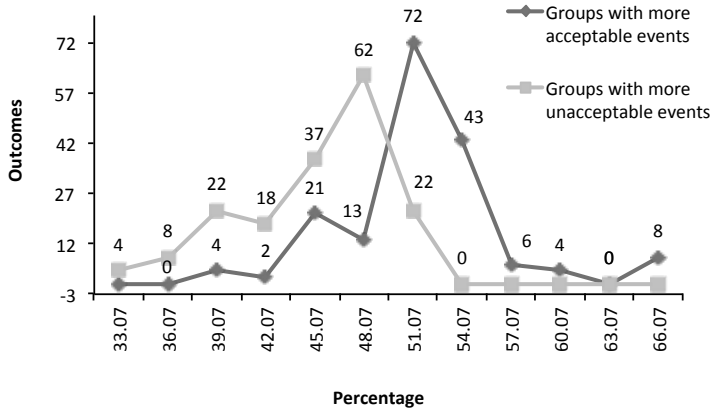


Figure 5.46: Simulations with most acceptable or unacceptable events

The aggregate, and corresponding percentile, number of simulations that ended with a full credit cycle with exactly the same number of acceptable or unacceptable endorsed events is depicted below in Figure 5.47. In this case one can notice that the percentiles, once again regarding collective credit ranging from three to seven participants, are lower –confirming the expectation that such results are less likely to occur.

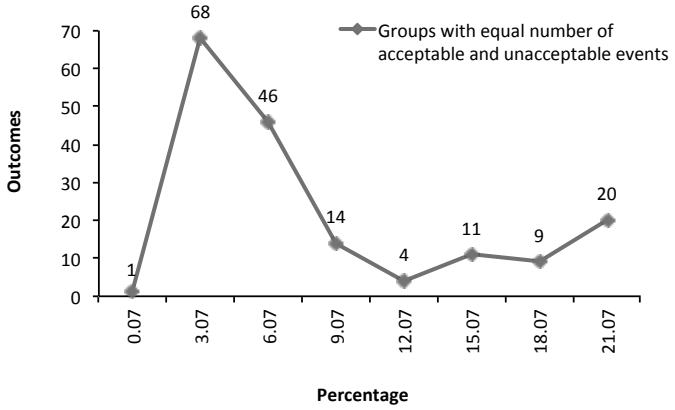


Figure 5.47: Simulations with equal number of both event types

5.4.2 Modelling Guidance and Impact on Policy-Making

When ABM results are incomparable to existing evidence, it becomes rather unclear what can be achieved from analysing a simulation dataset, apart from theoretical discussions and illustrations. Assessing to which extent social simulation models meet their aims and objectives beyond theory is still currently an experimental process of trials and errors. Given the broad scope of researchers' backgrounds working on ABM, there is a natural diversity of methodological aspects to be considered. One way that helps the identification and estimation of parameters for an ABM is behavioural data collection and analysis. This data is also useful as a reference for evaluating simulation results, otherwise only theoretical frameworks –which often require semi-arbitrary adaptations for implementation purposes– would be guiding the ABM development.

It is thus argued hereby that reliable evidence is a requirement for social simulation research that seeks usefulness both to academics and policy-makers. It is essential that modellers have an excellent contextual understanding of the phenomenon of interest to avoid, sometimes unknowingly and oftentimes unintentionally, embedding in their models highly speculative assumptions that diverge from actual evidence or stakeholder experience. The discussion put forward in 4.3: "Evidence-Driven Approach to Modelling (EDAM)" (page 86) contain suggestions on how modellers can minimise issues when developing ABM that are intended for purposes beyond theory by focusing mainly on qualitative and/or quantitative data. Evidence about a given social phenomena can be sourced by modellers from third-party sources[96], but as recommended in the aforementioned lifecycle, it would be preferable to establish a common understanding of the available behavioural data directly with the stakeholders. My experience whilst developing the ABM for this research thesis and all those other researchers interviewed by me[97], demonstrate that many unintentional misunderstandings can be avoided whilst modelling because of the direct access to stakeholders. This is a key advantage of integrating an EDTM in the development cycle of an ABM simulation.

[96] That is, people or organisations without direct participation in the researched case study.
[97] See Section 3.2.2: "Challenges in Simulating Social Phenomena with ABM" (page 61).

Summary and Conclusions of Chapter 5: Research Findings

This chapter contains all key research findings resulted from the design of data collection and analysis discussed in the previous chapter. These include detailed insights regarding fieldwork findings of both credit officers and microfinance clients. In doing so, the author has addressed the research problem of empirically investigating the behaviour, within microfinance groups, that enables members to cope with defaulters.

Furthermore, the two sets of research questions have been answered, regarding credit officers and credit clients. These consisted of, respectively, understanding: a) support, moral and ethics, b) perceived advantages and disadvantages of their microcredit framework and c) observed clients' actions regarding missed meetings and payments.

The second set consisted of understanding: a) the composition of clients' business and advice networks, b) the statuses of their group composition and credit and c) their typical actions regarding missed meetings and payments.

The methodological research question has also been addressed, which consisted of presenting an ABM exploration –under different conditions– of the role of individual behaviour within the collective responsibility imposed by a microcredit group.

Chapter 6

Final Discussions and Conclusions

This research is focused on the role of microfinance as a social enterprise that can provide an innovative public good to mitigate inequality and poverty. Microfinance has been adapted around the world since the 1970s, with different levels of scalability, and one reason for that –beyond financial management– is the increasing understanding of conventional behaviour. By carrying out an evidence-driven research design, an ABM has been built based on the data regarding *how* clients behave collectively in order to deal with defaulters and debt over time. A representation of behaviour has been tested via simulations in different configurations and insights have been discussed in terms of the similarity of the observed outcomes. The TOC below contain the contributions to knowledge and future research potential based on this thesis.

Contents

Although it is somewhat straightforward to define poverty and inequality, it is difficult –and sometimes also inappropriate– to use one absolute threshold across world regions. For this reason some of the key poverty assessment tools used by development organisations have been discussed in Section 2.4: "Usage of Poverty Lines in Social Enterprise" (page 41). A further understanding of the conventional social behaviour amongst microfinance clients in the case study based in Chiapas, Mexico, has been achieved via analysis of fieldwork data and testing of an ABM built based on the research findings. The latter has been developed according to the discussion put forward in Section 4.3: "Evidence-Driven Approach to Modelling (EDAM)" (page 86) and Section: 4.3.1: "Developing an Ethnographic Decision Tree Model (EDTM)" (page 91). That took into account data from 635 stakeholders and an assessment of whether research findings could be useful for policy-making. Evidence reported in Chapter 6: "Final Discussions and Conclusions" (page 165) corroborate to the understanding of how social collateral has been managed by group participants over time.

According to the analysed data, peer selection is endogenous and evidence suggests that it is also geographically bound as a self-organised way for the MFI to effectively screen and monitor group members. These are manifested as social and financial sanctions over those not conforming with the group conventions. Another key finding was that a significant number of financed groups were formed by relatives[1], despite the original MFI prohibition of such practice[2]. Other studies have reported similar results, for example: research on 146 groups in Madagascar [Zeller, 1998], 137 groups in Guatemala [Wydick, 1999, Sanders and Nee, 1996] provide corroborative evidence that social ties and group conventions can lead to higher repayment rates and that the geographical distance between group members can impact behaviour of microfinance clients. This research has raised a similar suggestion as illustrated on Figure 5.25: "Histogram of all distances covered during fieldwork" (page 130) and the reported behaviour in Tables 5.13: "According to officers, what clients do when a meeting is missed?" and 5.14: "According to officers, what clients do when a payment is missed?".

[1] See Table 5.15: "Non-aggregated composition of the clients' business networks" (page 116).
[2] See discussion in Section 5.2: "Fieldwork Findings: Microfinance Clients" (page 116).

Thus one can see that there is a great variety of what does work in different communities. The research project discussed in this thesis is a contribution to the understanding and exploration of the microcredit clients' behaviour in Chiapas, Mexico, where family ties and location are suggested as an effective selection to screen, monitor and enforce behaviour amongst group participants.

The joint liability employed in group lending schemes provide many advantages to microfinance clients wishing to improve their living conditions and move way upwards in relation to a poverty line. Yet this may hinder the financial development of the most successful individuals in case these are unable –e.g. due to distance or inflexibility of the group lending framework– to form a group with members having a comparable repayment ability. In other words, when MFIs are unable to offer differentiated credit services, individuals who can borrow much more than other group members may either leave the collective lending framework or stick with the potential of being adversely affected by less successful clients.

During the one month observation of microcredit groups in Chiapas, the author has witnessed entrepreneur clients with considerably more credit than their peers experiencing difficulties in finding others with a comparable financial situation to prosper further. Therefore, as markets are essentially pools of individual agents dealing with incomplete information, joint liability offers a powerful means to aid the smooth functioning of MFIs by reducing information asymmetry and moral hazard[3] between lenders and borrowers[4]. In the case of this research project, joint liability is managed only at the group level and the reported behaviours by the surveyed stakeholders have lead to a model of decision-making.

[3] By transferring most responsibility of screening, monitoring and enforcement to clients.
[4] Assuming a context whereby the participants' financial circumstances are somewhat alike.

6.1.1 Contribution to Knowledge: Conventional Behaviour

There is an empirically grounded suggestion, based on the fieldwork findings, that microfinance groups in this case study vary composition and social behaviour according to location. The suggestion is that: those based in rural areas appear to be formed mainly by relatives, who in turn may prefer the administration of social pressure as a sanction tool. On the other hand, groups based in urban areas appear to be mainly formed by unrelated neighbours, who may then prefer the administration of group-level fines as a sanction tool. Eliciting the existence of these circumstances has contributed both to stakeholders and academics to the understanding of how microcredit groups deal in practice with the collective responsibility of making social collateral work. The fieldwork evidence for this is discussed throughout sections 5.1: "Fieldwork Findings: Credit Officers" and 5.2: "Fieldwork Findings: Microfinance Clients" (pages 101, 114).

The most relevant aspects of the aforementioned social conventions have been built into an EDTM representation of decision-making within MFI groups, and then further explored with an ABM implementation. Such conventional social behaviour is likely to have coexisted with other strategies for dealing with defaulters and collective debt. It is also plausible that there is –amongst those groups belonging to the same credit centre– a continuous learning and asynchronous evaluation process about different approaches. Further research would be needed to understand in detail how the transmission and assessment is carried out within and across groups. The fact that credit officers travel periodically to where clients live may be a relevant aspect to consider in this regard. Due to different transportation circumstances, there could also be an interesting variation between rural and urban groups. The suggested conjecture is that different social conventions are tested over time to manage defaulters, with the less effective strategies being abandoned in favour of the better ones. The research findings presented shed new light on how social collateral in microfinance is dealt with at the group level in the researched MFI. This contribution to knowledge is thus anchored in the detailed analysis of the social conventions reported by the surveyed stakeholders in Tables 5.13: "According to officers, what clients do when a meeting is missed?" and 5.14: "According to officers, what clients do when a payment is missed?" (page 113).

6.1.2 Contribution to Knowledge: Policy-Making

Involving stakeholders in the research process was instrumental to clarify eventual misunderstandings and provide them with at least a partial sense of ownership regarding the new knowledge generated in this project. Both aspects facilitated the liaison provided between researchers and stakeholders. The research design and findings are highlighted throughout Chapter 4: "Research Design and Development" and Chapter 5: "Research Findings" (pages 75 and 100, respectively) and were taken into further account by stakeholders to consider changes in their financing policies because:

- (a) of the fact that some decision-makers participated in all stages of the process of eliciting new information through fieldwork –either directly whilst surveys were being designed or indirectly by supervising how these were being administered. During the modelling and implementation stages, due to funding restrictions, it was no longer possible to be inasmuch contact as during the fieldwork.

- (b) it was easier to relate fieldwork findings, both in terms of time and scale, to a known state of the socio-economic phenomenon, as some of what has been reported could still be observed –or remembered– by those involved in it[5].

- (c) the unfamiliarity of policy-makers with concepts and techniques of ABM resulted in some level of scepticism when interpreting results obtained from the simulation model. This further influenced difficulties in keeping up good and frequent communication, once the modelling process begun. Yet, fieldwork findings provided influential insights that helped the MFI to improve their regulatory framework. This consisted of piloting, in a phased fashion, the encouragement –instead of the previous prohibition– of microfinance groups formed by relatives.

[5] See Section 3.2.2: "Challenges in Simulating Social Phenomena with ABM" (page 64) and the discussion in Section 5.4.2: "Modelling Guidance and Impact on Policy-Making" (page 163).

6.1.3 Contribution to Knowledge: Building of an ABM

Given the critique on the state-of-the-art of social simulation, this research has –from the very beginning– focused on how to improve the status-quo in terms of producing more useful results to the involved stakeholders. This effort was carried out throughout the project and is discussed in detail in the recommendations put forward in Section 4.3: "Evidence-Driven Approach to Modelling (EDAM)" (page 86), which includes:

- (a) the provision of a systematic and verifiable means of restricting modellers regarding which aspects should be added into a simulation and which should be left out from it, aiming at more practical contributions. That is, evidence-driven modellers take the available data insights as the main guide to assess what is essential to be in a simulation model from what shall be considered contextual information, and needed to understand each scenario of a social phenomenon.

- (b) the encouragement of modellers to inductively elicit information and knowledge about the specific phenomenon. This can be done using the proposal in Section 4.3.1: "Developing an Ethnographic Decision Tree Model (EDTM)" (page 91), with periodical checks with stakeholders during the administration of the following steps in the lifecycle of the ABM development: data collection, data analysis and selection of assumptions, representation of behaviour and processes, then finally the discussion of the ABM simulation findings with domain experts.

- (c) a participatory design that can help stakeholders to better understand what an ABM is, how they can influence its development and what are the limitations of such approach. Given the demonstration of how an EDTM can help guide the development of an ABM simulation, there is a good potential for substantial contributions by exploring phenomena with such quasi-experimental approach. That is because simulated data can provide insights that would otherwise be unavailable to mediate discussions between researchers and stakeholders.

6.2 Future Research

Along with the summaries of the contributions to knowledge in the previous sections, there are three particularly interesting suggestions for future research based on this thesis. The first would follow up what has changed in the MFI as a result of this research. The second is about exploring different ways in which the ABM could be used and/or extended. And the third is about carrying out a social network analysis.

An innovation the MFI has considered, based on the behavioural insights, is the implementation of a system for payment and management of credit via mobile phones. Clients would be able to pay due quotas and receive credit without needing to attend the regular meetings. This would influence how the social conventions discussed in this thesis operate and adapt, as then mobiles would open new ways to transfer money, communicate with group members and arrange how to deal with their defaults. There is good potential for mobile banking in the microfinance industry, both as a means to repay credit to the financing institution and for peer-to-peer money transfers. This could reduce operational costs, speed-up data collection/analysis and reduce the risk of officers being robbed en route to/from their clients –as witnessed during fieldwork.

Group lending essentially depends on the response of MFIs to the difficulties arising from dealing with numerous small loans and, in developing countries, usually the microfinance market is dense (i.e. containing both many clients as well as service providers) [ILO, 2002]. An alternative approach to model the micro-level decision-making process which clients engage to deal with defaulters could be via mechanism design (i.e. game-theory). Behaviour in groups is essentially an expression of social choice. Thus based on a good understanding of the participants' behaviour, one could propose a function that evaluates in detail each of the key adversities a client can experience. This would lend itself to a transactions costs perspective, as then one can attempt to minimise the burden of collective monitoring and enforcement.

6.2.1 Research Potential: Following-up the Findings

The MFI stakeholders did implement changes in their policies based on the research findings presented in this thesis. Having a reliable, evidence-driven means of assessing their clients' behaviour was deemed on par with assessing the client's levels of poverty as a way to better inform decision-making. This involved further training of their credit officers to update existing PPI surveys, to collect behavioural data per group, and integrate this into their information system. Based on this the MFI has been able to:

- offer opportunities for longer (monthly) payment cycles in new financial services, to test a policy that encourages family members to form microfinance groups;

- introduce greater flexibility in existing MFI services, so that individual clients with good performance may apply for extra credit independently from groups;

- confirm the lacking of client training is linked with groups not repaying credit, prompting the MFI to capacitate their credit officers to ameliorate this issue;

- verify that clients with at least five years of experience tended to be above the PPI-defined poverty threshold and that the majority of dropout clients actually have a similar financial portfolio if compared to their typical newcomer client.

This research project has been able to provide the MFI stakeholders with new knowledge that influenced funding policies, based on insights regarding how their microfinance groups work internally. These aforementioned actions taken by the institution have also been used as examples of innovations in subsequent fundraising bids. Thus a natural follow-up of this research would be to analyse trends, and adapt the exploratory ABM, based on the data that has been collected about the microfinance groups.

6.2.2 Research Potential: Applicability of the ABM

Considering that ABMs are compact representations, in the sense of reducing the phenomenon of interest to a minimum set of elements and processes, there is a great potential for these models to be used in educational settings. The relative ease and flexibility that these models have allowed users to quickly test the effects of changing parameters in a model can, in this way, serve as a research tool to facilitate the communication and discussion of selected intricacies of the phenomenon itself.

The ABM in this thesis has allowed an exploratory assessment of processes that involve asynchronous social interactions that would not be possible to analyse without a computer simulation. An ABM is thus a flexible approach for modelling specific properties and mechanisms of a complex social phenomenon, which can complement other quantitative and qualitative approaches. In this case, the model has illustrated plausible outcomes about the dynamics of behaviour within microcredit groups in different scenarios. This could be further extended and researched with an ABM.

The MFI managers assessed simulation results as viable, yet regarded fieldwork findings as more directly useful for decision-making. Social simulation is perhaps best understood as a complementary approach to facilitate –along with more traditional quantitative and qualitative methodologies– better descriptions of complex social realities, such as role of social collateral in microfinance. Note however that this does not imply social simulation results can be used for accurately forecasting what-if scenarios. The suggestion put forward here is simply that the social simulation should provide: (I) a relatively well understood[6] set of illustrations about scenarios of interest, and also (II) less ambiguous representations and explanations than purely textual (i.e. discursive) accounts of scenarios about a social phenomenon that one wishes to better understand.

[6] Both in terms of its scope, limitations and overall applicability according to its validation.

6.2.3 Research Potential: Social Network Analysis

The imperfect information (asymmetry) approach to joint liability –operationalised via social collateral–, has been discussed throughout this thesis as a useful framework to understand the general rationale behind the design of group lending frameworks. Yet few studies describe what groups empirically do to successfully self-organise. Whilst developing this research project, the author has also noted the potential for a social network analysis to contribute with new knowledge about the inner dynamics of social collateral through analysing the clients' social networks. Examples include: a) identifying different types of individual centrality within groups, b) researching how behaviour in different groups may be interconnected, and c) providing a generative approach to the statistical properties of the observed networks using the Exponential Random Graphs approach. These could provide powerful insights on the statistical properties of networked social collateral.

There is potential to further investigate the structure of microfinance business and advice networks. For example it would be useful to know, in case of recovered defaults, who actually lends how much money to whom in a group. This would shed new light on the details and trends as to how defaulters are dealt with over longer periods of time than a cross-sectional study. This would also improve our understanding of the dissemination of conventional behaviour–and not the already established patterns. That could lead to findings that would hone other MFI policies aimed at encouraging what is considered to be desirable behaviour within the financed groups.

Last but not least, intelligible visualisations of credit networks[7] could facilitate the analysis and discussion of statistical insights. Modellers and MFI stakeholders could benefit from being able to visualise the structures of networks in the light of credit transactional data. This could be achieved with a user interface that is intuitive enough, that the researcher or MFI analyst could provide the users with results on demand.

[7] Cross-sectional and, if available, longitudinal illustrations of the different network states.

Chapter 7

Appendix

This section contains all supporting material referenced in this thesis. The fieldwork reports were developed and written by Pablo Lucas, who acknowledges the useful discussions held with Federico Morales and Ignacio García. The first appendix includes the four surveys focused on behavioural aspects of microfinance clients and officers. The second, third and fourth appendix contain the anonymised reports. Every report originally written in Spanish has been translated into English and were discussed, from 2008 to 2009, with researchers at the CFPM, Manchester Metropolitan University and at the World Institute for Development Economics Research, United Nations University (UNU-WIDER) in Helsinki. Reports were first written in Spanish to facilitate the discussion with the microfinance stakeholders in Chiapas and at PROIMMSE-IIA.

Contents

7.1 Appendix I: Fieldwork Surveys

QUESTIONNAIRE 1

Dear **advisor**, Our aim is to study the impact of trust and its relation to quota repayments amongst micro-credit group members promoted by you. Your answers will only be used in a research project being developed to better understand behaviour within micro-finance groups. Your participation is voluntary and anonymous. Thanks indeed for participating.

Municipality: _____ Area: _____ Language: _____

1. Number in ORDER OF IMPORTANCE the disposition CAUSES to pay quotas. Number 1 is the most important.

_____Honour group agreements _____Credit conditions _____Economic profitability _____Solidarity
_____Mutual monitoring _____Peer pressure among group members _____ Other causes

2. Describe what do you understand by "SOLIDARITY GROUP"? Could you provide examples?

3. If a quota is NOT PAID, what are the most important CAUSES?
a) _____ ; b) _____ ; c)_____ ; d)_____

4. What are the ADVANTAGES of the solidarity lending methodology?

5. What are the limitations of your methodology? When and why it does not work well?

6. Mark which of the following LANGUAGES you commonly use to communicate with groups.
Tsotsil, Tseltal, Chol, Tojolabal, Zoque, Mam, Spanish, Other _____

7. Which moral or ethical principles (solidarity, for example) are present where you work?

8. Do ethical or moral principles from question 7 support trust and quota repayment amongst group members? Can you explain how these occur?

9. Which moral or ethical principles (solidarity, for example) do you miss where your work take place?

10. How the absence of moral or ethical principles from question 9 affect trust and quota repayment within groups?

11. What happens with group members when one of its participants:
a) Is not attending meetings. b) Is not paying on time.

12. Do you know the economical activities of every group where you work?
a) All them ( ); b) Most of them ( ); c) Some of them ( ).

13. Apart from moral or ethical principles, what other aspects should be considered to improve microfinance groups?

QUESTIONNAIRE 2

Dear **client**, Our aim is to study the impact of trust and its relation to quota repayments amongst micro-credit group members promoted by you. Your answers will only be used in a research project being developed to better understand behaviour within micro-finance groups. Your participation is voluntary and anonymous. Thanks indeed for participating.

1. Associate number:_____ Name: _____ Reference number:_____

2. Who would you ask personal advice?

Name_____
Is the person in your group? Yes ___ No ____
This person is your: relative _____ neighbour ____ friend _____ business partner ____
You ask this person: always _____ sometimes ____
Where is this person living? ( ) in the same area_____ ( ) Which other area? _____

Name_____
Is the person in your group? Yes ___ No ____
This person is your: relative _____ neighbour ____ friend _____ business partner ____
You ask this person: always _____ sometimes ____
Where is this person living? ( ) in the same area_____ ( ) Which other area? _____

Name_____
Is the person in your group? Yes ___ No ____
This person is your: relative _____ neighbour ____ friend _____ business partner ____
You ask this person: always _____ sometimes ____
Where is this person living? ( ) in the same area_____ ( ) Which other area? _____

3. With who would you collaborate in a business activity?

Name_____
Is the person in your group? Yes ___ No ____
This person is your: relative _____ neighbour ____ friend _____ business partner ____
You ask this person: always _____ sometimes ____
Where is this person living? ( ) in the same area_____ ( ) Which other area? _____

Name_____
Is the person in your group? Yes ___ No ____
This person is your: relative _____ neighbour ____ friend _____ business partner ____
You ask this person: always _____ sometimes ____
Where is this person living? ( ) in the same area_____ ( ) Which other area? _____

Name_____
Is the person in your group? Yes ___ No ____
This person is your: relative _____ neighbour ____ friend _____ business partner ____
You ask this person: always _____ sometimes ____
Where is this person living? ( ) in the same area_____ ( ) Which other area? _____

4. Do you know the projects being developed by every member in your group?
a) No ( ); b) Yes, all them ( ); c) Yes, some of them ( ).

5. What is it done when one of your group members:
a) Is not present at meetings? _____
b) Is not paying on time? _____

QUESTIONNAIRE 3

Dear **adviser**, after analysing data from the first questionnaire answered by you, we have prepared few more questions to enhance our understanding about the solidarity groups. Please, remember that your honest opinion is very important. Thanks for participating.

1. How have you selected the clients to interview?

2. What are the main DISEASES that cause DEFAULTING?
a) b) c)

3. What are the main CAUSES of LACK OF RENTABILITY among clients' projects?
a) b) c)

4. What are the main CAUSES of LACK OF INVESTMENT among the clients' projects?
a) b) c)

5. How frequently is it BOTH to MISS MEETINGS and PAYMENTS?
(a) NOT frequent. (b) Occasionally. (c) VERY frequent. (d) No answer.

6. How frequent is it to MISS MEETINGS but PAY ON TIME?
(a) NOT frequent. (b) Occasionally. (c) VERY frequent. (d) No answer.

QUESTIONNAIRE 4

Dear **adviser**, after analysing data from the past 2 questionnaires answered by you, we have prepared few more questions to enhance our understanding about the solidarity groups. Please, remember that your honest opinion is very important. Thanks for participating.

1. Are SOCIAL PRESSURE and SANCTIONS stronger in RURAL or URBAN areas?
(a) RURAL. (b) SAME in both areas. (c) URBAN. (d) No answer.

2. Are FINANCIAL PRESSURE and SANCTIONS stronger in RURAL or URBAN areas?
(a) RURAL. (b) SAME in both areas. (c) URBAN. (d) No answer.

3. Are there more RELATIVES within groups based in RURAL or URBAN areas?
(a) RURAL. (b) URBAN. (c) No answer.

4. In which areas are the most entrepreneurial clients based?
(a) RURAL. (b) URBAN. (c) BOTH. (d) No answer.

5. In which areas do you observe most DIVERSIFIED businesses supported by your methodology?
(a) RURAL. (b) URBAN. (c) BOTH. (d) None.

6. In Which areas do you observe most clients with best ability to handle INDIVIDUAL CREDIT?
(a) RURAL. (b) URBAN. (c) BOTH. (d) None.

7. In which areas do you observe most clients using all their common credit in the SAME BUSINESS?
(a) RURAL. (b) URBAN. (c) BOTH. (d) None.

8. In which areas do you observe most INTERMEDIARIES between micro-credit groups and their clients?
(a) RURAL. (b) URBAN. (c) BOTH. (d) None.

7.2 Appendix II: First Fieldwork Report

Dynamics of social conventions in microfinance groups: an experience in Chiapas, Mexico.[1]

Pablo Lucas[1], Ignacio Garcia[2], Federico Morales[3]

[1]Centre for Policy Modelling (CFPM), M13GH, England.
[2]PROIMMSE-IIA-National Autonomous University of Mexico
[3]Facultad de Filosofía y Letras, Universidad de Buenos Aires

pablo@cfpm.org, nachologia@yahoo.com.ar, fmorales@unam.mx

1 Introduction

This report synthesises initial results from studying effects of social conventions on how solidarity groups promoted by a micro-finance institution (MFI) work and evolve over time in Chiapas, Mexico. Due to our publishing agreement, their identity is omitted. This research is part of Pablo Lucas research project entitled Conventional social behaviour amongst microfinance clients, micro-credit.no-ip.org at CFPM, and Ignacio Garcia at Buenos Aires University. Findings are presented along with our strategy for capturing data using questionnaires to credit advisers and clients. Suggestions to a new MFI information system are also included.

2 Data Collection Strategy

Most discussions related to microfinance have not dedicated much attention to internal mechanisms amongst microfinance clients, where the so-called Solidarity Group (SG) concept is central to its success. A SG means the individual or group-wide decision to cover losses from a defaulting member, with or without fines. Little is actually known about how penalization and group liability is managed by clients themselves, and arguably the detailed influence of conventional social behaviour in these cooperative processes is even less understood. Some metrics fallaciously emphasise that such data and processes analysis should not take social contexts into account, or that cultural differences are not relevant. However, as this study exemplifies, sanctions and cooperation amongst clients belonging to micro finance groups can be directly related to community-specific social structures and their understanding of what is considered acceptable behaviour.

Aiming to study effects of local social conventions on micro finance groups promoted by the MFI, two types of questionnaires were designed: one to better understand the seasoned experience of credit advisers on their fieldwork tasks, plus another oriented to uncover social behaviour and structural composition of groups. All advisors were questioned twice using online forms and, additionally, semi-structured verbal interviews were recorded during our fieldwork visit. The first questionnaire contained 14 questions, and some months later 6 other online questions followed-up. LimeSurvey.org was used in a Debian.org serving Apache.org with PHP.net and MySQL.org database in Manchester, England. The clients' questionnaire contains 5 questions and was administered by MFI advisers. A translation of all questionnaires is available as an annex at the end of this document. The MFI director instructed them to select 3 people per day in each different visited administrative centre. Figure 1 depicts the criterion used by advisers to choose interviewees, grouped into categories according to how answers can be unambiguously interpreted.

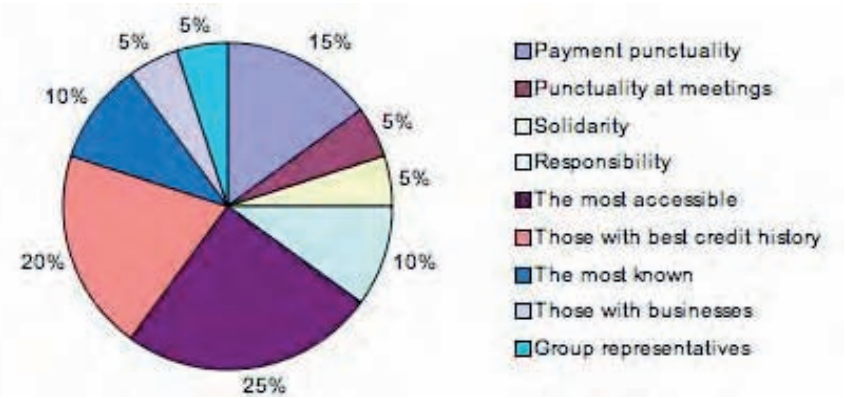


Figure 1: Advisers' criteria to choose interviewees (data from the 2nd questionnaire).

1 Spanish version, presented to the MFI, is dated June 14th 2008. Translated on June 16th 2008. Latest review: May 12th 2010.

2.1 Codifying Questionnaires

From a total of 24 questions designed to credit advisers and clients, 13 were open-ended. That is, with data fields allowing free text as input. These ones along with recorded interviews were codified according to a matching criterion based on the Grounded Theory, in which every analysed answer was semantically grouped in wider categories following their sequential order. This process allowed statistical analysis and graphical representations of every emerging category by interpreting the data set whilst verifying categories with the domain experts at the MFI in Chiapas.

The usual difficulties with codifying open-ended questions were minimised as most answers contained concepts that were very similar and in line with language used both by advisers and clients, in Spanish or one of the following Mayan languages: Tsotsil, Tseltal, Chol, Tojolabal, Zoque, Mam. This was verified with them during visits in May 2008. Decision-making diagrams in the last page of this document are based on analyses combining all sourced data show clients' and adviser's observed behavioural patterns.

3 Credit Advisers' Questionnaires

The most relevant results so far obtained are presented including the composition of both administered questionnaires online and semi-structured verbal interviews with some credit advisers. The first questionnaire was answered by 35 employees, whilst 34 for the 2nd. *Nota bene:* The graphical formats of the annexed forms are slightly different as these were administered via a website.

3.1 First Questionnaire

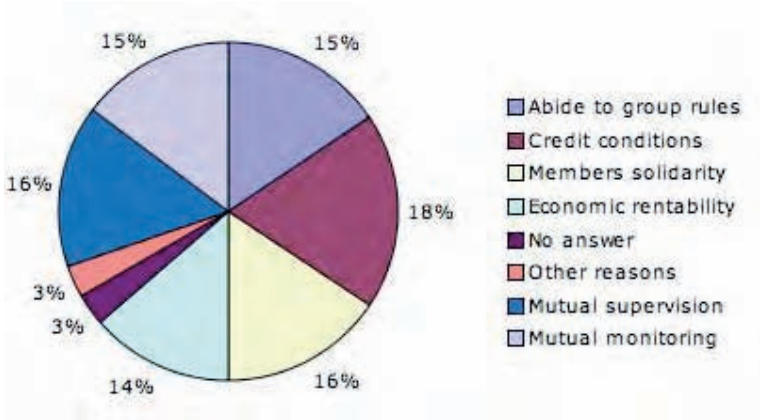


Figure 2. What most influence on time quota repayments?

According to credit advisers, a combination of the following reasons is the most important for group-wide credit liquidity: economic profitability (14%), keep group agreements (15%), mutual monitoring (15%), group vigilance (16%) and credit conditions (18%).

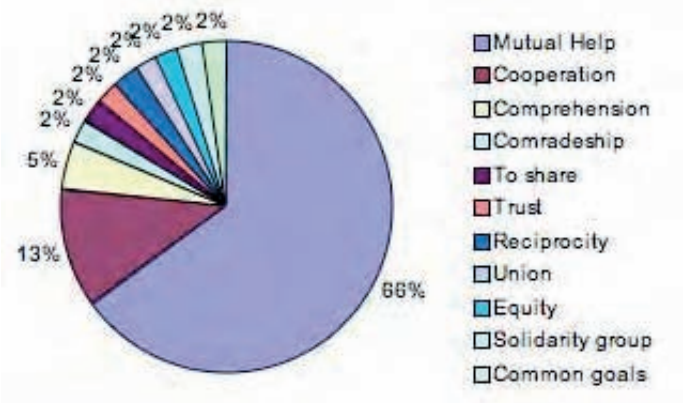


Figure 3. What microfinance SG stand for?

Figure 3 depicts the vast majority of credit advisers (66%) identifying the SG concept as mutual help, which in this context reinforces the strong sense of reciprocity amongst clients and not necessarily pure altruism.

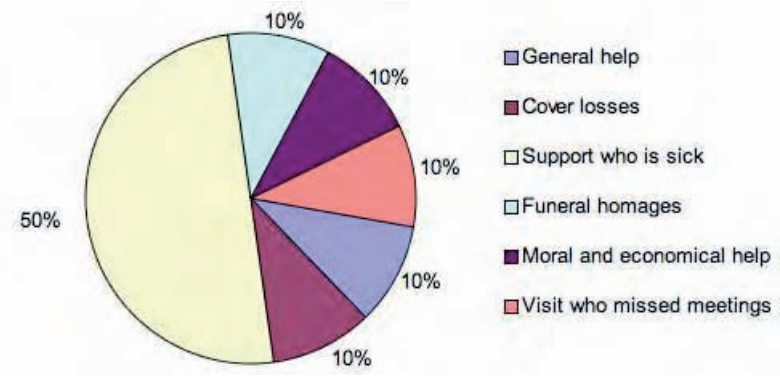


Figure 4. Examples given by advisers of what SGs do.

About 90% of all answers included specific manifestations of help, whilst just 10% of all answers actually made references to mutual monitoring mechanism within credit groups as an example of solidarity.

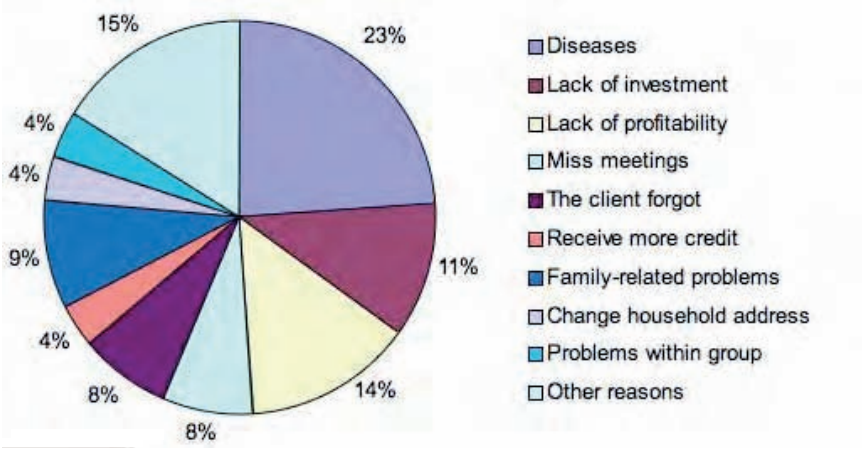


Figure 5. Why clients miss payments?

The 3 main reasons perceived by advisers are: diseases, lack of profitability and lack of investment. Data collected in the 2nd questionnaire, presented in the next section, contain more details on each of those aspects.

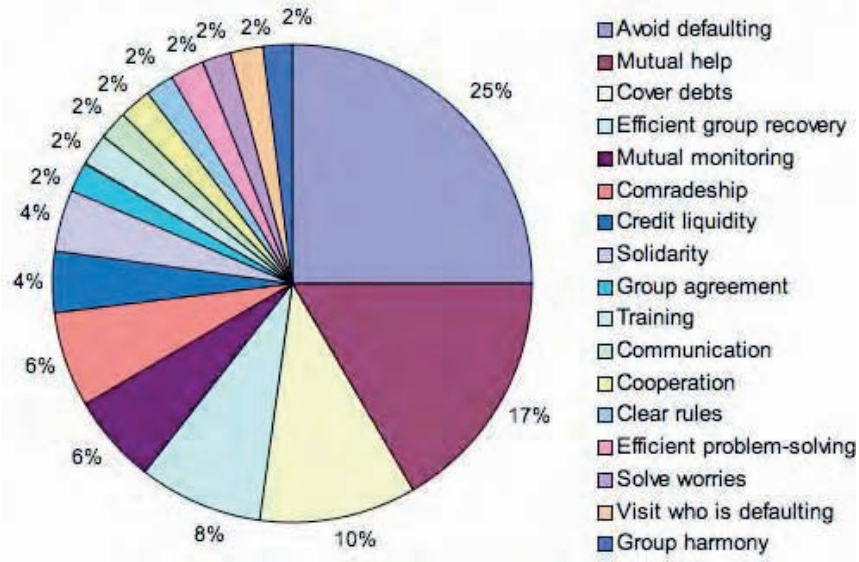


Figure 6. What are the advantages of microfinance SGs?

The fundamental perception, verified both at interviews during the fieldwork and questionnaire data, is that a SG is an efficient mechanism to obtain financial resources and tie individual responsibilities in groups. Otherwise financial risk would increase to unsustainable, or very unstable, levels and there would be no other alternative to enforce desirable behaviour. As otherwise, mutual responsibility and social monitoring would simply not exist.

Topic	Categorised Answers
Credit quotas, time and applications.	Slow authorisations, impossibility to pay quotas in advance, mandatory investment, only available to groups, lack of monthly repayments, inflexible repayment dates, some clients want higher progressive credits and the initial credit amount is too low.
Communication	Advisers get late visiting administrative centres, insufficient communication, which as a consequence may lead to misunderstandings and wrong information.
Meetings	Mandatory presence of all clients, very strict rules to attending meetings, clients are not willing to feel like students, absent people and lack of time to conduct tasks.
Late payments	Lack of juridical support, or safer methods to recover losses and other charges.
Groups	Lack of control due disorganisation, badly oriented solidarity groups, difficulties when clients have never worked together and distance between households.
Various non-frequent issues	Persistence of untrustworthiness, difficulties generated by misunderstandings about group solidarity scheme, disinterest amongst clients and advisers not keeping rules.

Table 1. What are the disadvantages of microfinance SGs?

Advisers perceive the methodology as over-regulated, or perhaps not enough flexible. The numerous issues categorised in Table 1 are put forward as limiting the leeway and how fieldwork operations are conducted.

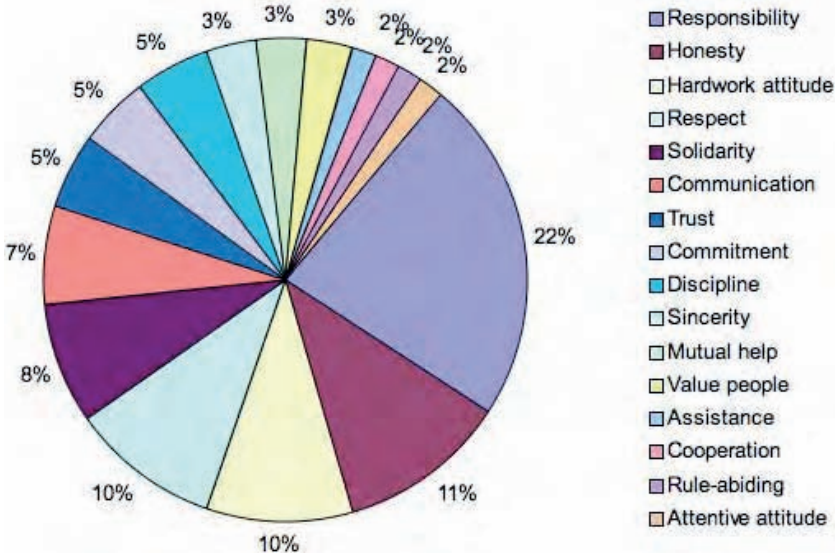


Figure 7. Existent clients' moral and ethical principles.

Honesty, hard-working attitude, respect and solidarity are perceived as the main ethical or moral principles observed amongst microfinance clients. These factors, amongst other socio-economical issues, are crucial to support MFI-imposed rules related to ensure the SG methodology in microfinance (see Figures 7 and 8).

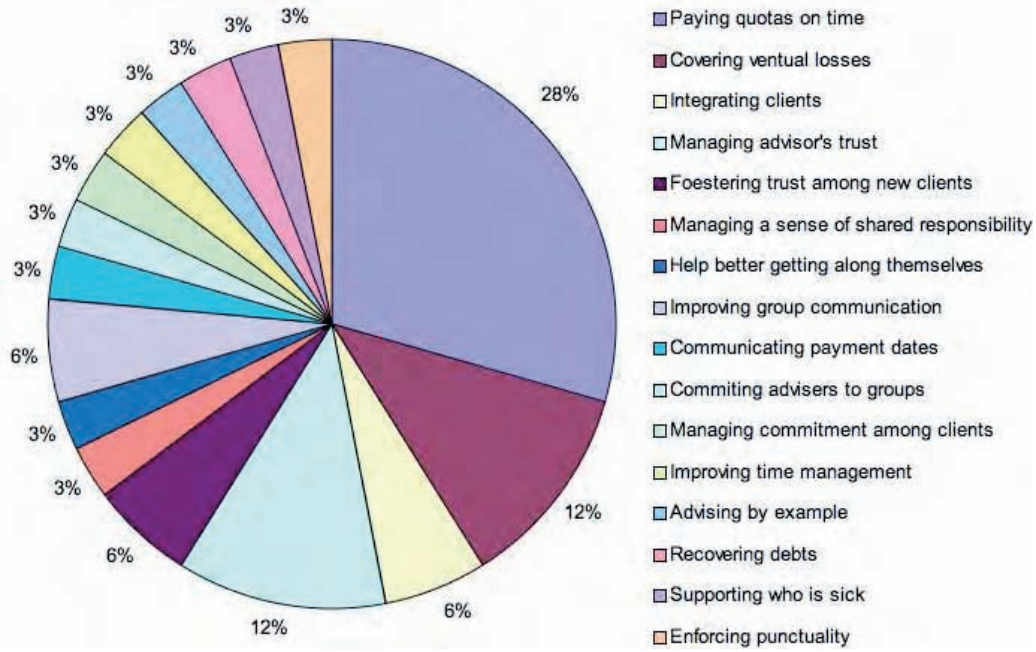


Figure 8. How does data from Figure 7 support trust and repayments?

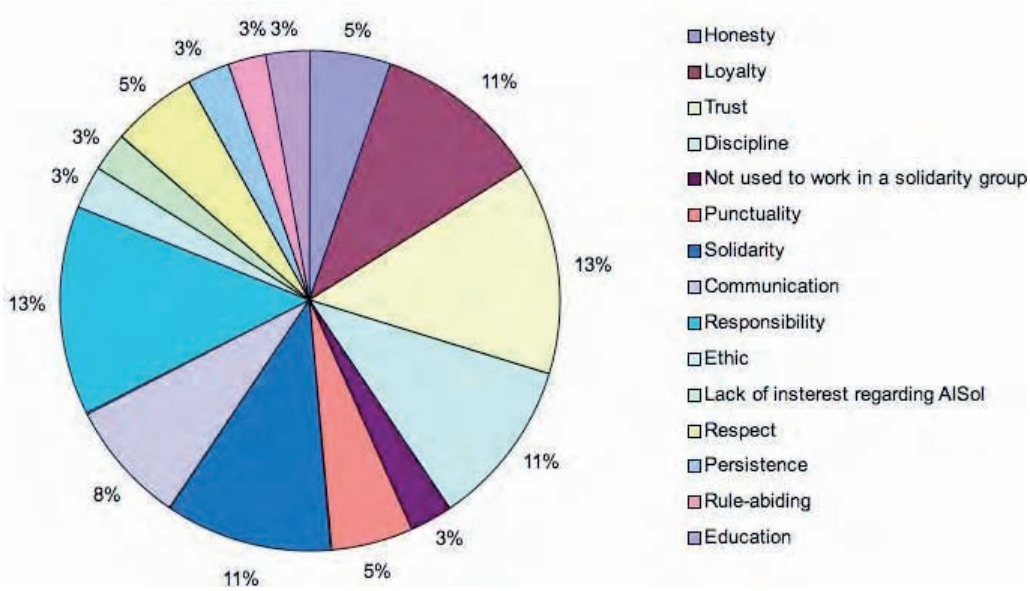


Figure 9. Moral and ethical principles not observed amongst clients.

On the other hand, irresponsibility, untrustworthiness, indiscipline and non-cooperative behaviour are generally considered as the most negative attitudes to the success of a micro finance group (Figures 9 & 10).

Topic	Examples
Missed quota repayments	It is hard to recover missed payments and to control individual deposit sheets.
Disorganised administrative centres	Miscommunication, lack of integration, untrustworthiness, conflicts amongst clients and disbelief that microfinance can actually help in economic terms.

Table 2. How the missing moral or ethical principles in Figure 9 affect micro finance groups.

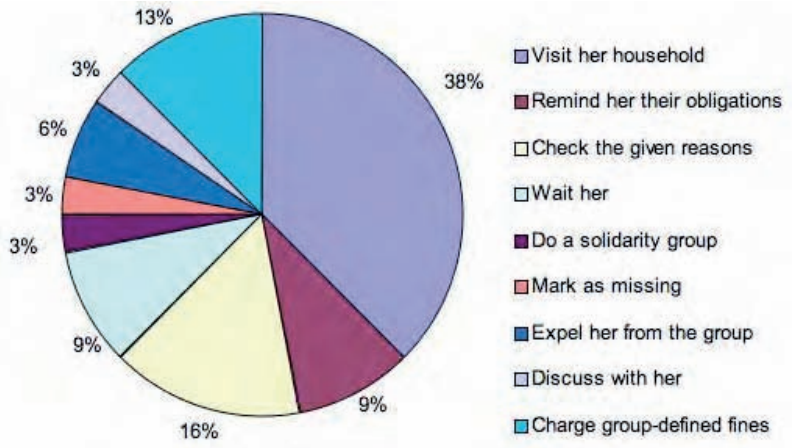


Figure 10. What microfinance borrowers do when someone misses a meeting?

As seen in Figure 10, visits to defaulting clients' homes by advisers, group representatives or the whole group, is clearly the most employed mechanism to exert social pressure. In Figure 11, another equally high percentage can be observed in terms of cooperative behaviour when some payment is not made on time.

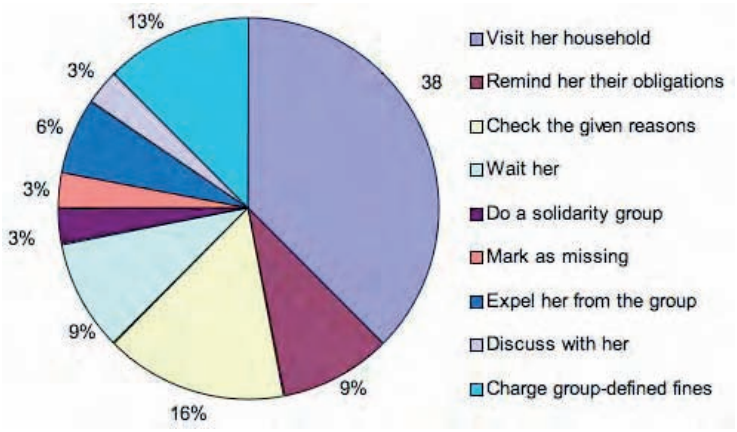


Figure 11. What do microfinance borrowers do when someone misses a payment?

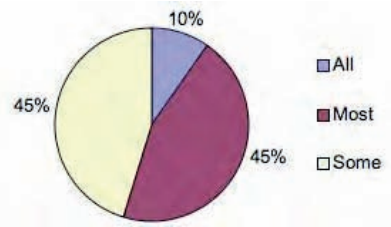


Figure 12. Post-credit business monitoring and consultancy provided by advisers.

Albeit stated in their good practice guide, advisers are clearly facing difficulties in this sense (Figure 12).

Topic	Improvement Suggestions	What should be kept in mind
Finance	Foment voluntary savings within groups, deposit smaller guarantees after receiving new credit, and better tracking of late-payments.	Contribute with accurate information, how to support debt collection, efficient and considerate attention with clients.
Operation	Take more into account meetings' feedbacks, better explanation on what solidarity means for the MFI, improve social focus with clients.	Efficient service to clients, promote respect / trust amongst groups & advisers (specially to deal with illness and losses).
Methodology	Adapt MFI rules to clients in certain areas, keep the continuous training program, plus provide motivation and self-esteem workshops.	Trust clients to discuss social and economical issues, whilst introducing the concept of an MFI solidarity group.

Table 3. Understanding a SG.

In addition to Figures 7, 9 and Table 2, advisors suggested what to focus to improve the MFI fieldwork.

3.1 Second Questionnaire

This second form was used to collect additional data about defaulting members that appeared in the first one.

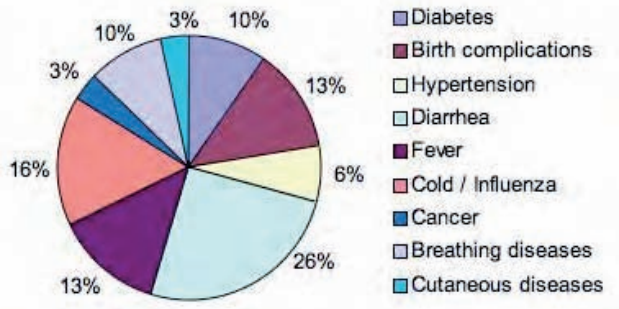


Figure 13. Which diseases usually induce clients to miss payments?

The reported diseases are mainly inline with long-established poverty studies, which directly links poor socio-economical areas with precarious hygiene and preventable medical conditions (Figure 13).

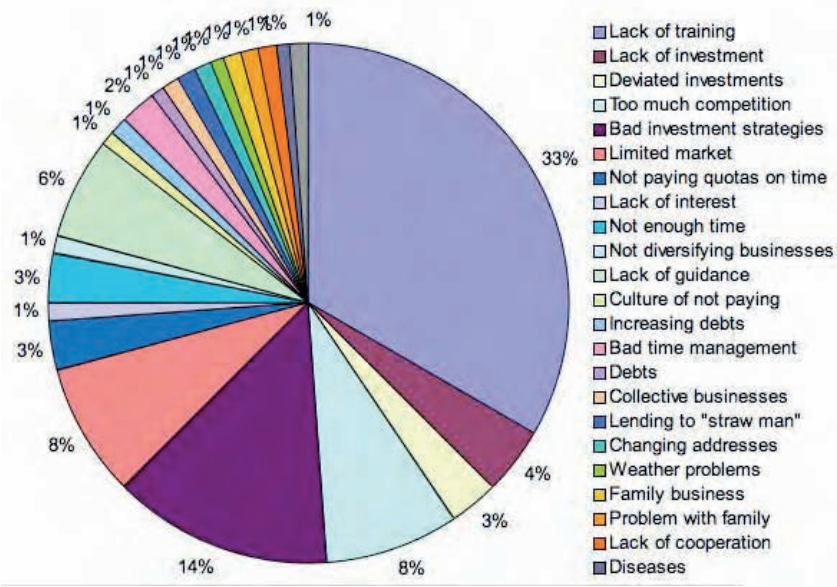


Figure 14. Why lack of profitability persists?

Advisers clearly have difficulties to provide business-specific consultancies as there are numerous economic projects facing diverse range of problems. Nonetheless, as most issues related to lack of profitability are linked to incomplete investment strategies, excessive competition and unidentified potential markets, it is suggested hereby the need for developing evaluative methods that can assist in doing a better diagnosis of local markets both from the advisers and client's perspective (Figure 14).

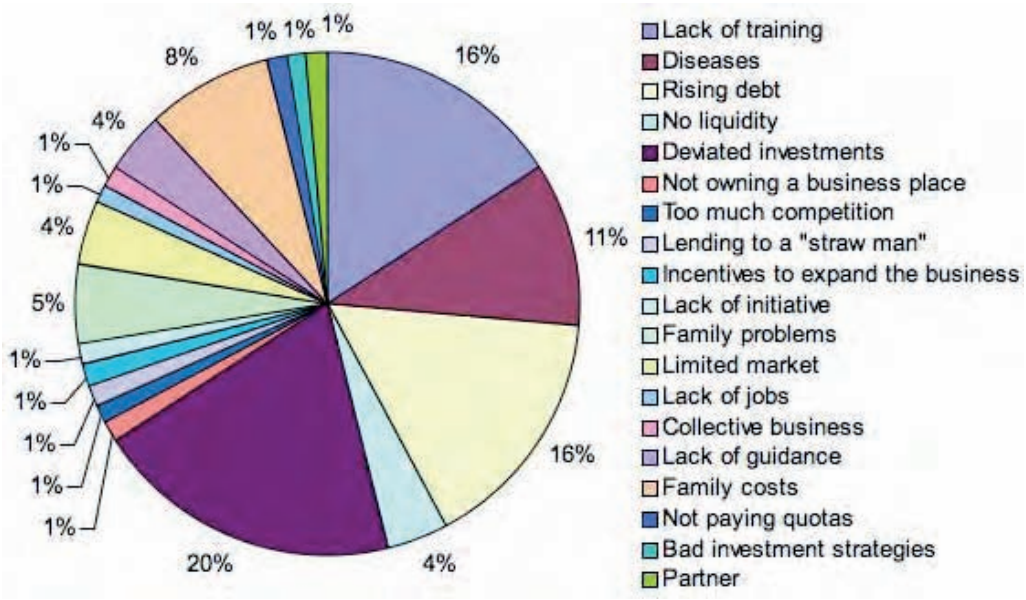


Figure 15. Why lack of investment persists?

Figure 15 show multiple debts, along with lack of training and using credit elsewhere, as the main undermining causes affecting businesses that should be receiving micro-credit investments.

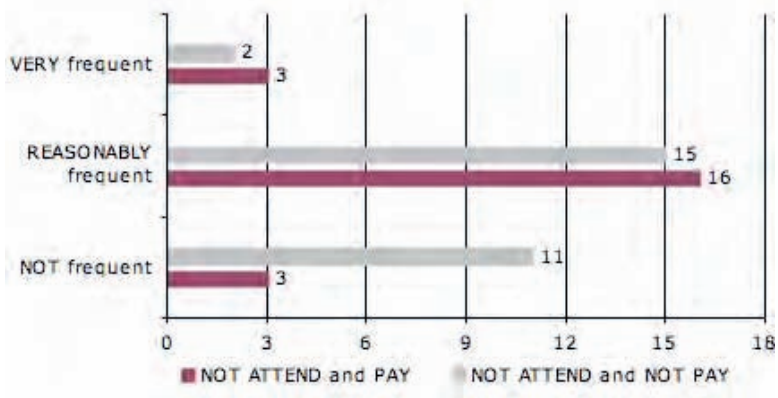


Figure 16. Payment and missed payment frequencies, in relation to meeting attendance.

In Figure 16, some answers can have multiple interpretations: (a) 25% of data is clearly coherent denouncing cases with lots of clients missing meetings yet not their payments (combination of high non-attendance rate and quota-payments, but little frequent to not go and not pay). (b) 68% are cases where both indicators have low frequencies, where a possible interpretation is that the vast majority of clients are missing meetings. Finally, (c) 8% indicates high frequencies for non-attendance and quota-payments. Would it be possible to have a high non-attendance rate yet, at the same time, have many cases of payments and non-payments over the existence period of a group? In this sense, it is suggested to discuss these findings with experienced advisers at the MFI, as it seems the best way to obtain a more precise interpretation about (b) and (c).

4 Clients' Questionnaire

The main results from the 600 interviewed clients are shown in the next page. The administered form was designed to collect structural information about how members are individually linked to each other, plus their internal monitoring and penalization mechanisms. It should be noted that, based on the results obtained from the first question given to the advisers in the second questionnaire depicted in Figure 1, most successful and active clients were the prioritised interviewees.

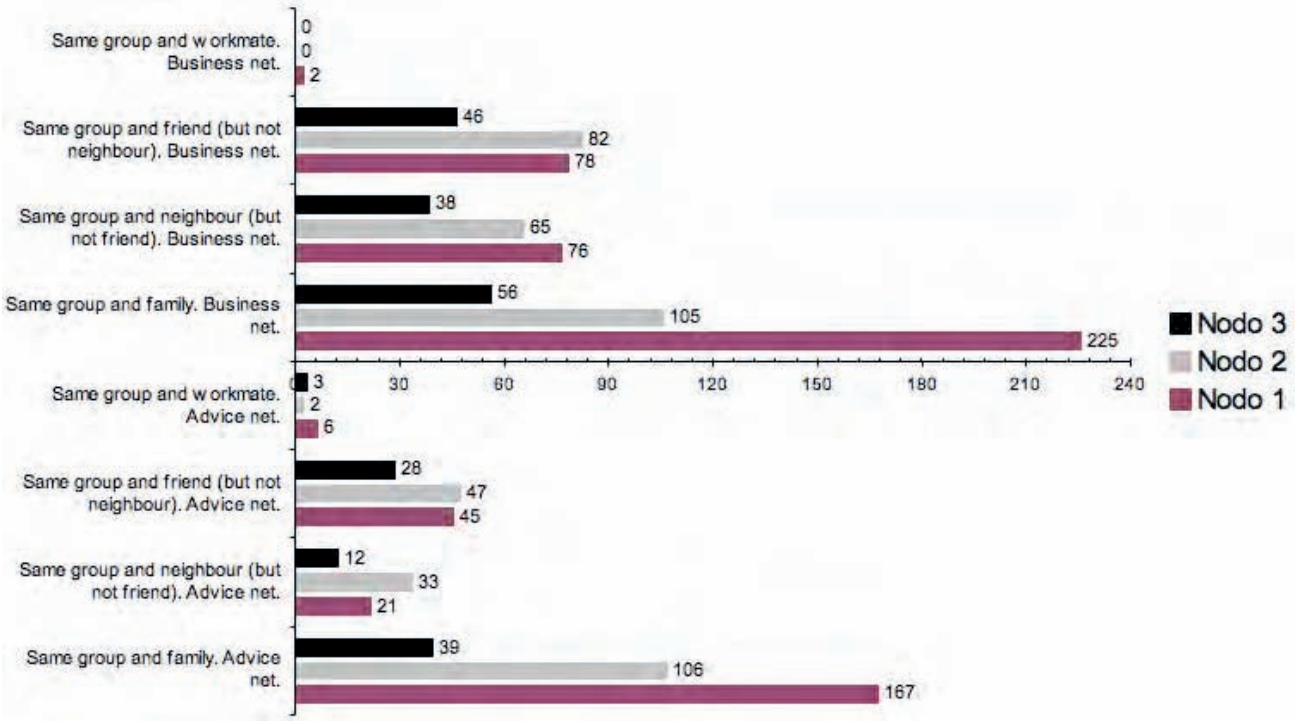


Figure 17. Relationships amongst interviewed clients.

The first studied structure in Figure 17 refers to trust amongst people, where it is notable the high percentage of group members who are family members. The second type of registered relationships is related to the cooperation in economic projects. In this case, albeit with a lower percentage, it is significant the fact that large numbers of interviewed clients work in stable income-generating groups formed by family members.

The financial evidence reinforces this finding as most of these groups are stable over longer credit cycles and are economically more successful. Given the MFI explicitly forbids such compositions, it was suggested that perhaps such compositions could actually be motivated instead of constrained. As the MFI have been adapting the Grameen Bank methodology for more than 10 years, probably this rule regarding family members, which seems to make sense in Bangladesh, can be changed to take advantage of this strong cultural influence that even pushed clients to break an MFI policy in Chiapas for their own good.

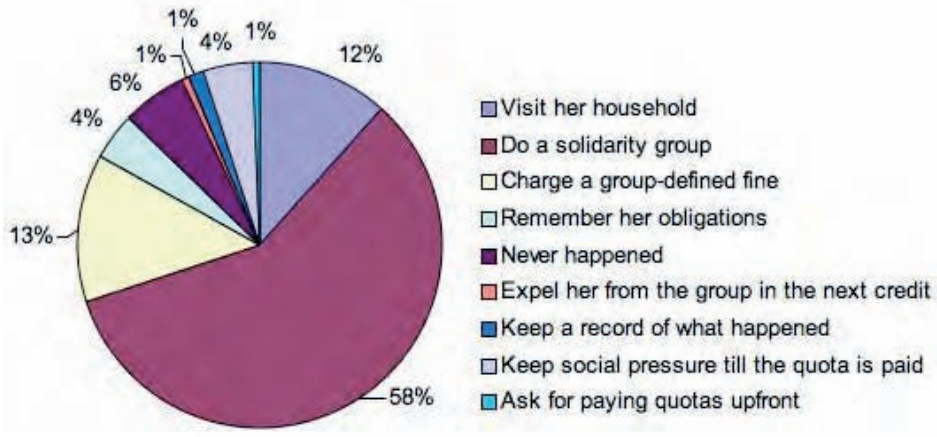


Figure 18. Mechanisms for: mutual monitoring and penalisation.

As mentioned in Figure 10, the mutual monitoring in the MFI solidarity groups is strongly expressed by visiting defaulting member's homes after missing a meeting or quotas; by the group representative, credit adviser or the whole group. There is also empirical evidence that this social pressure is much stronger and effective in rural areas. In terms of penalisation, the clients themselves set a fine for those who are not fulfilling their obligations. This may include advisers too, for example, in case of being late to meetings at the administrative centres. Such financial sanctions are considered as ultimatums amongst clients and are clearly more frequent and involve higher sums in urban centres where the MFI is operating. Further investigation can verify a hypothesis, which came up during our fieldwork, that social monitoring and penalization strategies tend to be more severe in micro finance groups mainly formed by family members.

5 Summary of Results and Suggestions to the MFI

Illnesses, lack of profitably and investments are clearly the main causes that lead to defaulting clients. The first one is a real opportunity that this MFI can intervene by adapting its existent medical program to extend prevention schemes and tackle diseases, considerably enhancing the clients' quality of life. With regards the other two aspects, our suggestion is to liaison directly with local development policy-makers and executives in order to gradually structure and scale distributed financial services such as credit provided by this MFI.

This MFI has no systematic storage of evidence regarding social behaviour, mutual cooperation (SGs) that clients are often practising with credit advisers. The only wide-covered data are financial performance such as quota repayments, yet known information such as who covered losses in groups and other issues affecting their internal structure is not being registered. A very important recommendation is to include this type of information in the new system that is already being redesigned by your technological department staff.

In one of our fieldwork trips to a suburban area, it was possible to evidence how delicate and important is the event of covering someone losses by means of a SG scheme. As one group member missed that crucial meeting without sending her payment by other means, after much discussion, the group member with the highest income and credit, decided single-handedly to cover that loss on behalf of all others. After that, and without the adviser's interference, it was common sense amongst all group members that a high extra fine should be imposed to who missed the meeting and payment. This, amongst many other observed examples, is a clear example of a much-needed updated reinterpretation of microfinance methodologies. Unfortunately most academic and third-sector literature covers very little how their group members internally manage SGs.

During the fieldwork visits to rural and suburban areas together with credit advisers, another suggestion was made to use small electronic devices such as Personal Digital Assistants (PDA). This was later discussed with the MFI director. PDAs could be used to collect data about clients and administrative centres as an easier means of storing information and updating this MFI's central database. For example, every time credit advisers are back to the MFI, all data in every PDA could be quickly downloaded. Obviously it would be necessary to design a detailed plan on how this new technology can be employed in an efficient manner, especially in terms of physical security and logistic of storing sensitive data. In case this suggestion is deemed appropriate as part of the new system at this MFI, we could help with implementation strategies.

Additionally, whilst this research project is being developed, probably other suggestions will appear with regards to which information this MFI could register. This can be both useful to internally analyse performance in relation to clients' realities, and also to initialise the simulation model with social data that is more precise and up-to-date. There is no pretension that this innovative model can be used for predictive purposes, as it would be irresponsible to suggest such an application without a clear and safe methodology to validate results. This initiative is so far focusing on testing new scenarios to generate results that can then be analysed by the MFI management veterans.

The experience of doing this report unquestionably demonstrates the huge effort involved in collecting social data in bigger scales, as the process is relatively slow and requires a lot of dedication and collaboration. If is feasible to introduce simple procedures in this MFI's methodology to collect and store data that nowadays – many times – are only available informally or in paper, this MFI would be able to expand its own capacity and speed for analysing data with regards to how clients evolve over time financially along with relevant social aspects that has affected each individual during the existence of every group.

6 Acknowledgements

I would like to thank the MFI manager director, and all collaborators in Chiapas for helping so much with this research, particularly Argentinean anthropologist Ignacio García and Mexican economist Federico Morales Barragán. The activities hereby described were carried within the European Union research project "Emergence In the Loop: Simulating the two-way dynamics of norm innovation", supported by the Centre for Policy Modelling (cfpm.org), Swiss Federal Institute of Technology, Chair of Sociology, in particular of Modelling and Simulation (soms.ethz.ch) and Autonomous University of Mexico (proimmse.unam.mx).

MFI credit officers' 1st questionnaire, administered from Nov. 2007 and Feb. 2008. ***ANNXES***

Dear advisor, our aim is to study the relationship between trust and quota repayments amongst micro-credit groups promoted by this MFI. Your answers will only be used in this research project focused on better understand conventional social behaviours in micro-finance groups. Your participation is voluntary, anonymous and remember: your honest opinion is very important. Thank you!

Municipality: _____ Area: _____ Language: _____

Number in ORDER OF IMPORTANCE the CAUSES to pay quotas. If needed, use Other causes.
_____ Honour group agreements _____ Economic profitability ____ Solidarity ____ Peer pressure
_____ Credit conditions _____ Mutual monitoring ____ Other causes

Describe what do you understand by "SOLIDARITY"? Could you provide examples?

If a quota is NOT PAID, what are the most important CAUSES?
a) _____ ; b) _____ ; c)_____ ; d)_____

What are the ADVANTAGES of the solidarity lending methodology?

What are the limitations of the MFI methodology? When and why it does not work well?

Mark which of the following LANGUAGES you commonly use to communicate with groups.
Tsotsil, Tseltal, Chol, Tojolabal, Zoque, Mam, Spanish, Other _____

Which moral or ethical principles (solidarity, for example) are present where you work?

How can the ethical or moral principles in question 7 support trust and quota repayment?

Which moral or ethical principles (solidarity, for example) do you miss where you work?

How the absence of mentioned moral or ethical principles affect trust and quota repayment?

What happens when someone is: a) not attending meetings? _____ b) not paying on time? _____

Do you know the economical activities of every group where you work?
a) All them ( ); b) Most of them ( ); c) Some of them ( ).

Apart from the moral or ethical principles, which other aspects must be understood to improve groups?

MFI credit officers' 2nd questionnaire, administered from 15-05-08 14 14:15:44 to 16-05-08 18:41:12.

Dear adviser, after analysing data from the first questionnaire answered by you, we have prepared few more questions to enhance our understanding about the solidarity groups. Please, remember that your opinion is very important. Thank you.

How have you selected the clients to interview?

What are the main DISEASES that cause DEFAULTING? a) b) c)

What are the main CAUSES of LACK OF RENTABILITY amongst clients' projects? a) b) c)

What are the main CAUSES of LACK OF INVESTMENT amongst the clients' projects? a) b) c)

How frequent is to NOT ATTEND MEETINGS and NOT PAY?
(a) NOT frequent. (b) Occasionally. (c) VERY frequent. (d) No answer.

How frequent is to NOT ATTEND MEETINGS and SEND PAYMENTS?
(a) NOT frequent. (b) Occasionally. (c) VERY frequent. (d) No answer.

Clients' questionnaire, administered from Nov. 2007 to Feb. 2008.

Dear client, Our aim is to study the impact of trust and its relation to quota repayments amongst micro-credit groups promoted by this MFI. Your answers will only be used in a research project developed to better understand behaviour within micro-finance groups. Your participation is voluntary, anonymous and remember: your honest opinion is very important. Thanks for your collaboration.

Please, inform your associate number:_____ Name: _____ Reference Number:_____

Who would you ask for a personal advice?

Name_____
Is the person in your group? Yes ___ No ____
This person is your: family member__ neighbour___ friend ____ business partner ___
You ask this person: always _____ sometimes ____
Where this person is living? ( ) in the same area__ ( ) Which another area? _____

Name_____
Is the person in your group? Yes ___ No ____
This person is your: family member__ neighbour___ friend ____ business partner ___
You ask this person: always _____ sometimes ____
Where this person is living? ( ) in the same area__ ( ) Which another area? _____

Name_____
Is the person in your group? Yes ___ No ____
This person is your: family member__ neighbour___ friend ____ business partner ___
You ask this person: always _____ sometimes ____
Where this person is living? ( ) in the same area__ ( ) Which another area? _____

With who would you participate in a business activity?

Name_____
Is the person in your group? Yes ___ No ____
This person is your: family member__ neighbour___ friend ____ business partner ___
You ask this person: always _____ sometimes ____
Where this person is living? ( ) in the same area__ ( ) Which another area? _____

Name_____
Is the person in your group? Yes ___ No ____
This person is your: family member__ neighbour___ friend ____ business partner ___
You ask this person: always _____ sometimes ____
Where this person is living? ( ) in the same area__ ( ) Which another area? _____

Name_____
Is the person in your group? Yes ___ No ____
This person is your: family member__ neighbour___ friend ____ business partner ___
You ask this person: always _____ sometimes ____
Where this person is living? ( ) in the same area__ ( ) Which another area? _____

Do you know the projects being developed by every member in your group?
a) No ( ); b) Yes, all them ( ); c) Yes, some of them ( ).

5. What is it done when one of your group members:
a) Is not present at meetings?_____ b) Is not paying on time?_____

7.3 Appendix III: Second Fieldwork Report

Relating Financial characterisation of Microfinance Groups to Conventional Social Behaviour

Pablo Lucas, Centre for Policy Modelling (CFPM), Manchester, England, pablo@cfpm.org

1 Introduction

This second report synthesises results from studying the effects of social conventions within the internal organisation and evolution of micro-finance groups, also known as solidarity groups, at a microfinance institution (MFI) in southern Mexico. According to our publishing agreement, their precise identity and location is omitted. The next section contains interpretations of all collected data and graphs, drawing on answers from the second questionnaire to credit advisors and five financial databases. I thank the MFI director, their team, Federico Morales, Ignacio García along with the CFPM and Swiss Federal Institute of Technology for the support provided for this research.

2 Data analysis

Whilst data from credit advisors was collected using a Web-based questionnaire, financial data of groups and individuals were obtained by querying five MFI databases with help from their information technology administrator. All 600 clients were identified according to their location, name and membership number written on paper forms administered. Table 1 below shows a total of 261 identified groups. After the fieldwork, between September 2007 and May 2008, it became clear that 72% of groups were rural and 37% had the same amount of individual credit within their groups.

Total	Rural	Groups that renewed same credit	Average group	Credit equally distributed	No longer existent
261	72 %	37% (group max. 7, min. 3)	4 (1.21 std. dev.)	44% (8% new, 27% experienced)	21% since 03/08

Table 1: General characterisation of interviewed groups

The number of groups that no longer exist (21%) in the sample is comparable to the unusual 30% client exit rate registered by the MFI. This happened during a period in which three main problems entwined: (I) insecurity to manage credit in centres, (II) competition with other MFIs and (III) impossibility to offer higher credit to the most entrepreneurial clients. In Figure 1 (a) below one can interpret that many more experienced groups (latest) were interviewed than inexperienced ones (initial). It also demonstrates that, according to their databases, proportionally few groups manage more than 5 participants. In general group formation is concentrated between 4 and 6 members. When there are changes, there is a clear tendency to reduce their numbers and not add new ones. From 56 groups that changed, 41 have reduced the number of their members. Figure 2 and its explanation on page 2 illustrate this in more detail.

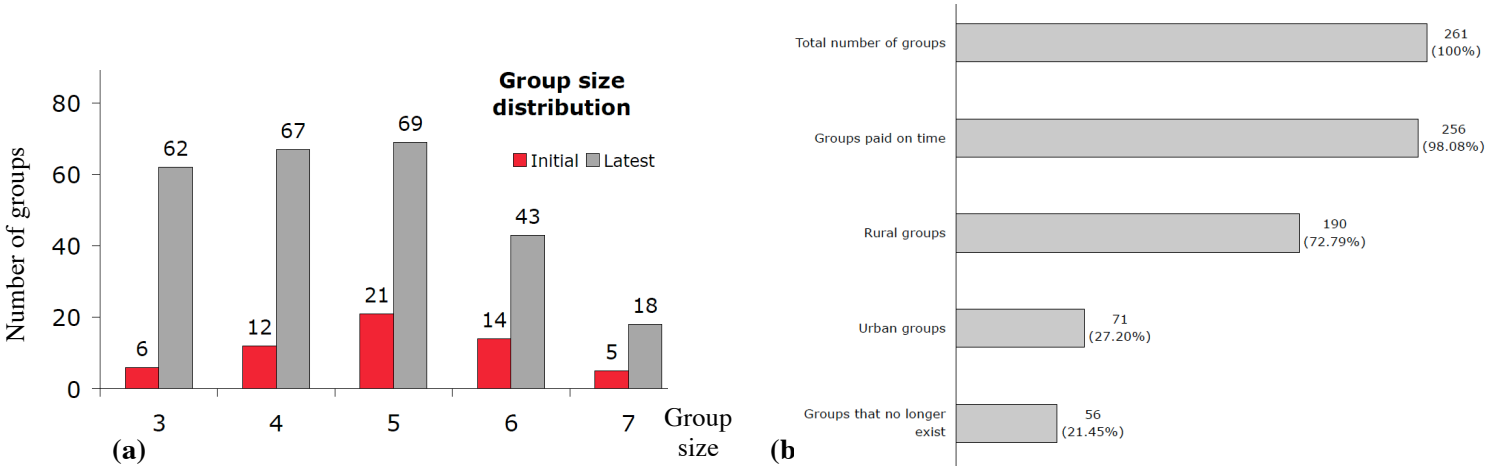


Figure 1: (a) Group size distribution of interviewed groups, and **(b)** General characterisation of these groups

Figure 1 (b) demonstrates that 98% of all groups have paid on time without fines. That is, only 5 were penalised: 4 rural, 1 urban. According to Figure 2, page 2, the regularity demonstrated by the vast majority of groups suggests that a considerable effort is involved in changing membership whilst debt is active, both from group participants and MFI employees. Nevertheless, if necessary, exclusion is still the most frequent event when groups changed (only 17 have added new participants). Expelling someone involves a combination of factors. One of these certainly relates to internal group evaluation mechanisms, adopted and evolved by clients themselves, to manage and discourage individual events of

defaulting or missing meetings at their local credit centres. This mechanism is illustrated in Figure 6 and explained in page 4. Another factor that seems important is the apparent instability generated by removing individuals. In Figure 2, one can see that most groups (23) have not lost credit as a consequence of removals, yet a close number (18) actually lost liquidity in this process. During the fieldwork, credit advisors commented that indeed exclusions could be difficult for groups, particularly when there are outstanding debts. Expelling is understood as extreme events, as these require social reassertion by all group members, as otherwise their cohesion and stability presumably would have been improved.

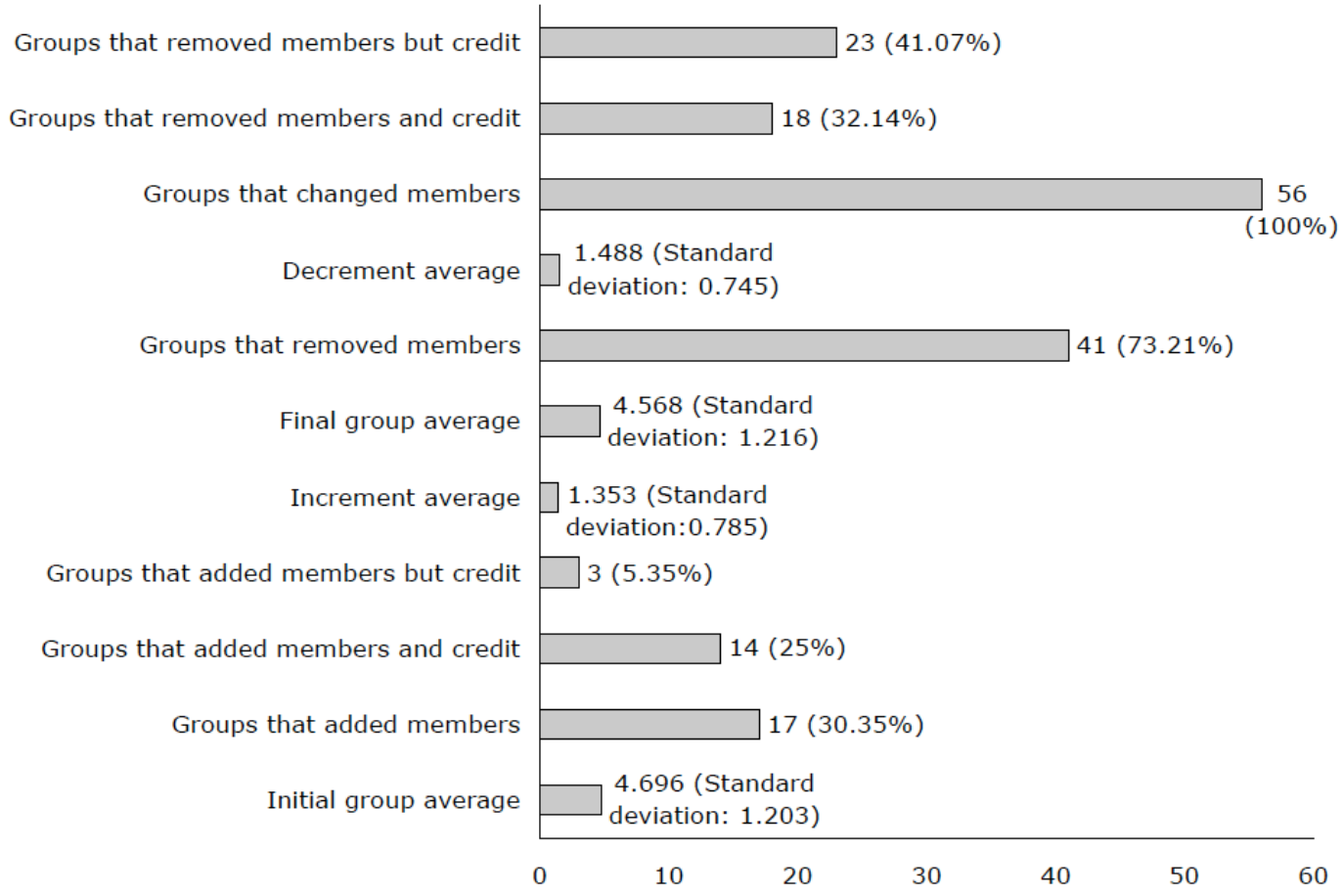


Figure 2: States of groups that changed over time

Having said that, it is necessary to consider that there are other possible justifications for someone to leave a microfinance group. Examples include: death, clients who leaving voluntarily in search of higher individual credit, disillusioned participants with high interest rates and, perhaps most frequently, clients that failed in their businesses. In order to better understand the most frequent causes of groups that shrink over time, the new (3rd) questionnaire to credit advisors includes a question where up to 3 reasons can be given to the question: "What are the most frequent causes for removing a group member?". The survey is ready to capture answers and it can be accessed at http://cuestionario-asesores.no-ip.org

A clear minority of 17 groups added new members and, as expected, most of these also had more credit. Only 3 did not gather more money with the increase of their group members. In these less frequent cases, it is possible that the original credit had simply been divided more as a consequence of the newcomer. This process may result in an equal distribution or not. It all depends on the particular circumstances of each group. There could also be restrictions both from who was already a member and specific MFI rules for such cases. Curiously the initial group size average (4.69) and final (4.56) are practically the same, along with their standard deviations of 1.20 and 0.78 respectively.

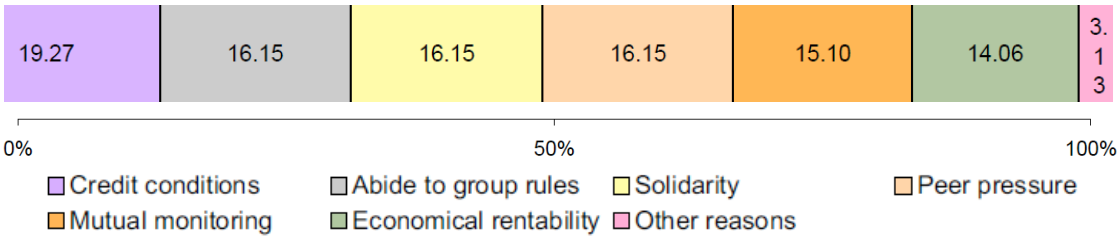


Figure 3: Success factors ordered according to their importance by credit advisors (grouped answers)

Figure 3 demonstrates that, when grouped, "Credit conditions" is the main reason (19.27%) behind successful groups. Answers such as "Abide to group rules", "Solidarity" and "Peer pressure" appear immediately after, each with 16.15%. The next one in order is "Economical rentability" (15.06%) and finally "Other reasons" (3.13%). Albeit representative, one must take into account the fact that when these answers are plotted individually (Figure 4), there are important differences in the distribution of those factors. "Abide to group rules" (between 34% and 37%), "Peer pressure" (between 15% and 31%) and "Mutual monitoring" (between 31% and 43%). This suggests that credit conditions are as important as the main individual aspects concerning social collateral with regards to the collective microcredit methodology.

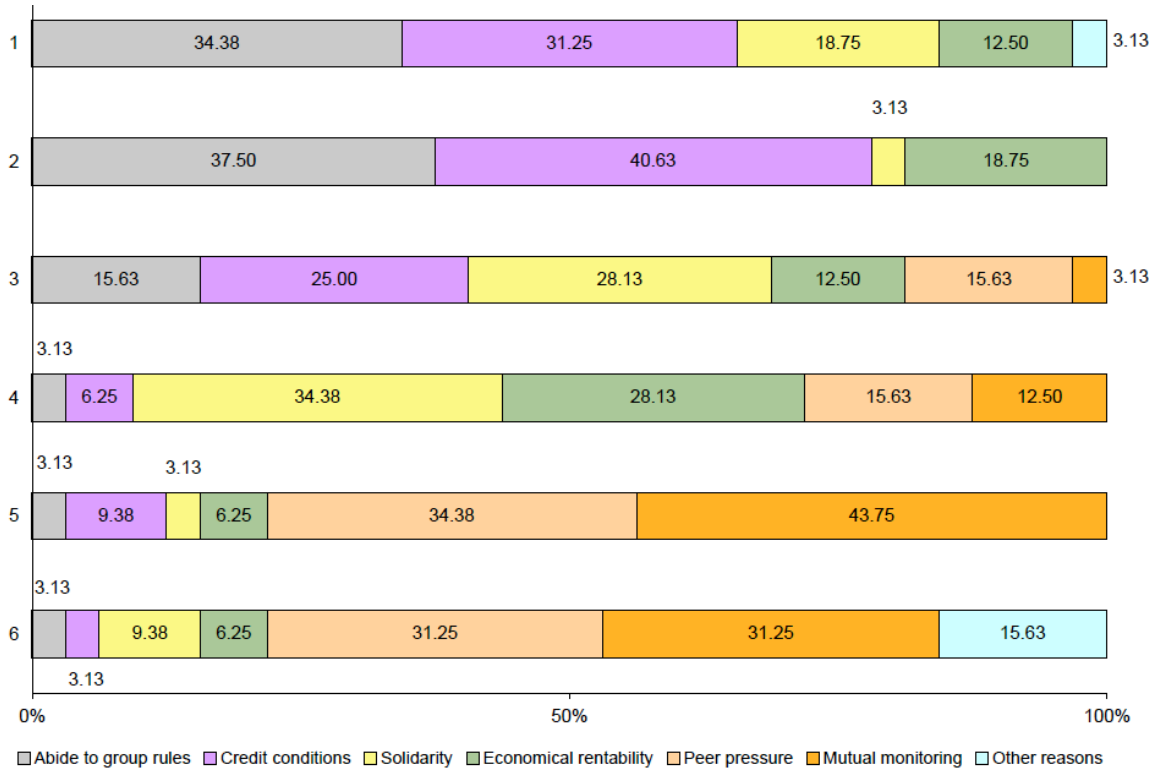


Figure 4: Success factors ordered according to their importance by credit advisors (ungrouped)

Figure 5 (a) below illustrates macro characteristics of most stable groups analysed during the fieldwork. Groups with new initial credits (20) are those that have only recently joined the MFI; or those that could have already renewed their previous instalments, as there are no outstanding debts. As a consequence, some of these may already have experienced how to manage and penalise defaulting members. Interviewed credit advisors confirmed that a learning process seems to take place in order for groups to internalise the conventional social behaviour depicted in Figure 7, which mainly deals with social pressure and consequences of unexpected behaviour by group members. Again, according to the fieldwork evidence, most new clients are currently recruited to the MFI exclusively by recommendations. There is no propaganda or taskforces to attract clients as during the beginning of their operations, when the MFI needed to expand into new areas.

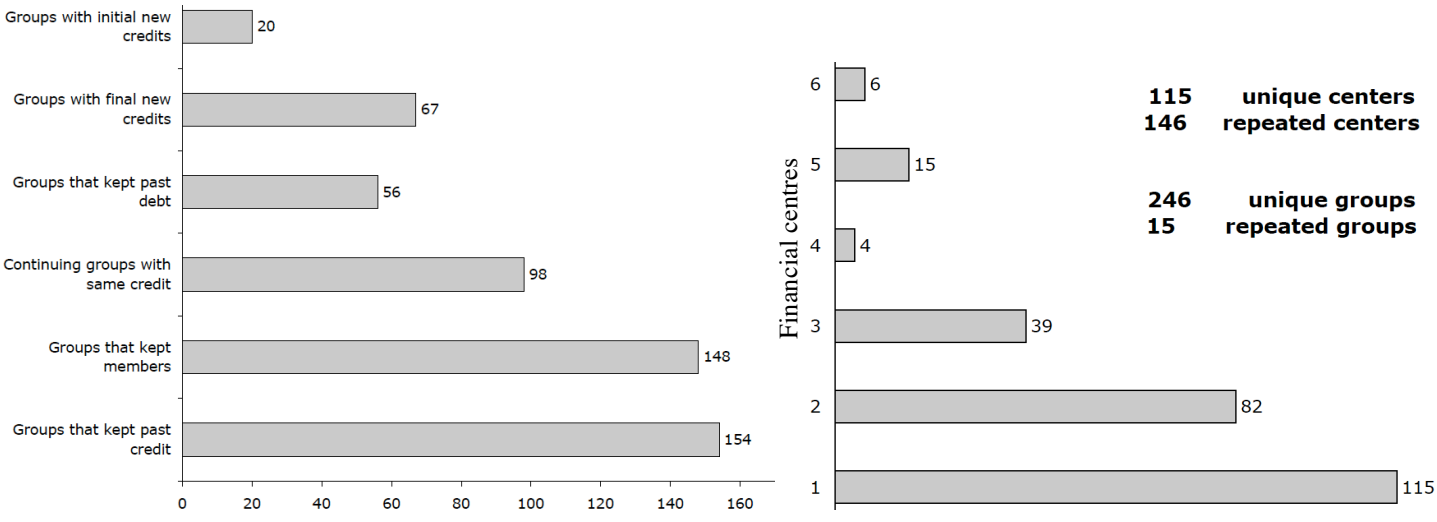


Figure 5: (a) Characteristics of most stable groups, **(b)** Distribution of interviewed groups per finance centres

Those experienced with microfinance are usually the ones who contact potential new clients. They inform where to find credit advisors and when their visit to local centres will take place. The main difference between the MFI in this case study and other institutions is the fact that clients are not required to manage debt and credit at their centralised branches. Instead, credit advisors travel to where clients live and setup a local finance centre there. This is important in the internalisation process and sharing knowledge about conventional social behaviour adopted at group levels. A feasible conjecture on the learning process is that different conventions, based on local social norms, have been tested over time with the objective of managing individuals throughout credit validity periods. Gradually, less effective strategies have been abandoned, whilst the alternatives with better results have been strengthened amongst the most successful groups. It is feasible that, at least partially, these experiences have been shared between other participants in credit centres. Information exchange about positive and negative strategies, albeit limited, is a probable way in which knowledge has been distributed amongst groups belonging to the same centre. The spread of these outcomes to different centres may have occurred with the help of credit advisors. Figure 5 (b), page 3, show a distribution that many analysed groups in this research came from different financial centres (115). The regularity in which penalisation within groups has been described suggests that there has already been an internalisation of adopted social conventions amongst interviewed groups and centres (Figure 5).

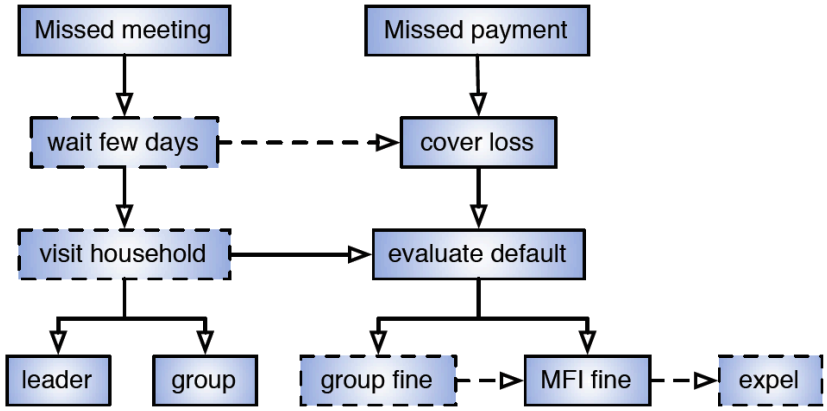


Figure 6: Mechanism identified for groups to internally manage and penalise individuals

Figure 6 above illustrates, according to the answers analysed from questionnaires and *in situ* interviews, the order and structure of social conventions adopted by clients to manage and penalise defaulting members. There are two main events that are evaluated by group participants: missed meetings and missed payments. Missing a meeting does not necessarily imply defaulting, as frequently someone else carries the quota payment on the client's behalf. Thus in case someone is missing during a financial meeting, clients usually wait for a while in case the person or some representative arrives late. If that is not the case, the group often covers defaulter's debts to avoid further MFI negative consequences. All members value such events event and those can lead to social pressure, most typically by visiting households of those have not paid on time. Each visit may involve the group representative or all group members; it depends on what they understand as the most appropriate for the occasion. As it is illustrated in Figure 7(b), clients usually cover losses, but often charge fines. During the fieldwork it was possible to witness how these events unfolded. Figure 7(a) illustrates the most common form of social pressure on those who missed meetings: visiting their households and verification of their reasons. Figure 6 was drawn based upon the structure of data acquired from 3 questionnaires and in-depth interviews about these 2 situations.

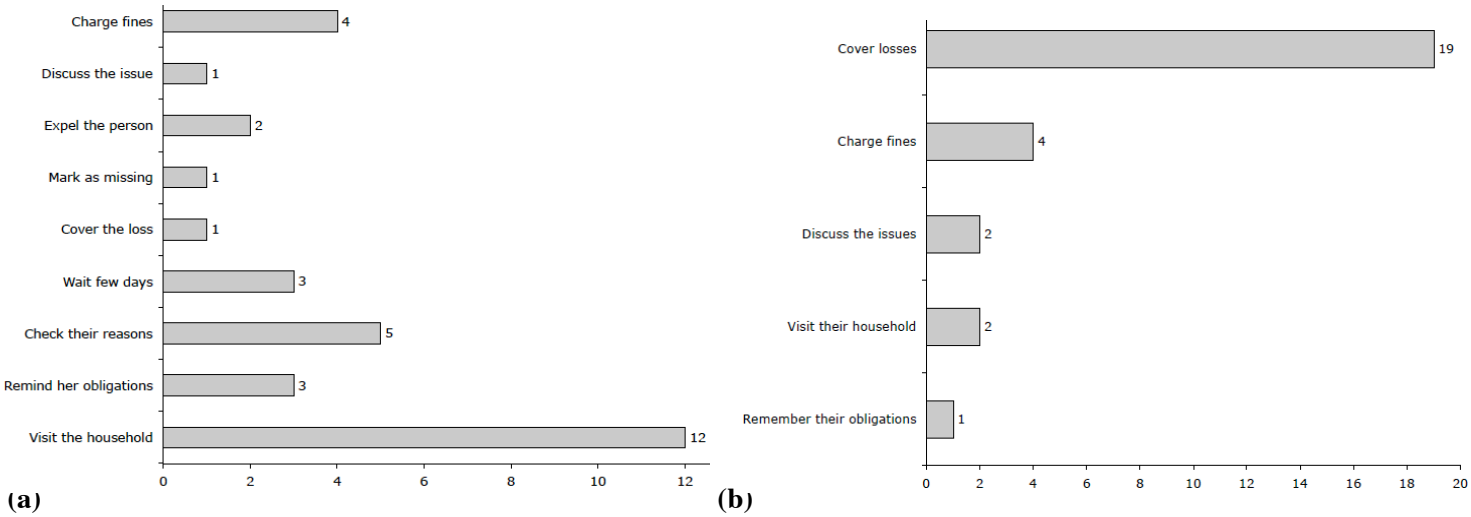


Figure 7: What clients do when someone: **(a)** miss meetings and **(b)** miss payments

Table 2 below contains the most common causes attributed to defaulting clients. According to the reasons commented by credit advisors in the second questionnaire administered (Figure 9), the diseases that most contribute to defaulting are: diarrheic diseases, cold / flu, birth complications and fever.

Causes	Percentage
Diseases	19 %
Other reasons	13 %
Lack of rentability	11 %
Poor investments	9 %
Family problems	7 %
Miss meetings	6 %
Negligence	6 %
Have other credits	3 %
Address change	3 %
Group problems	3 %

Table 2: Most frequent defaulting causes

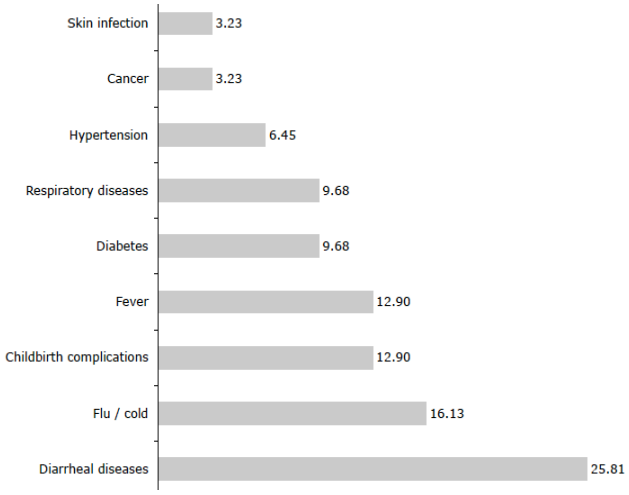
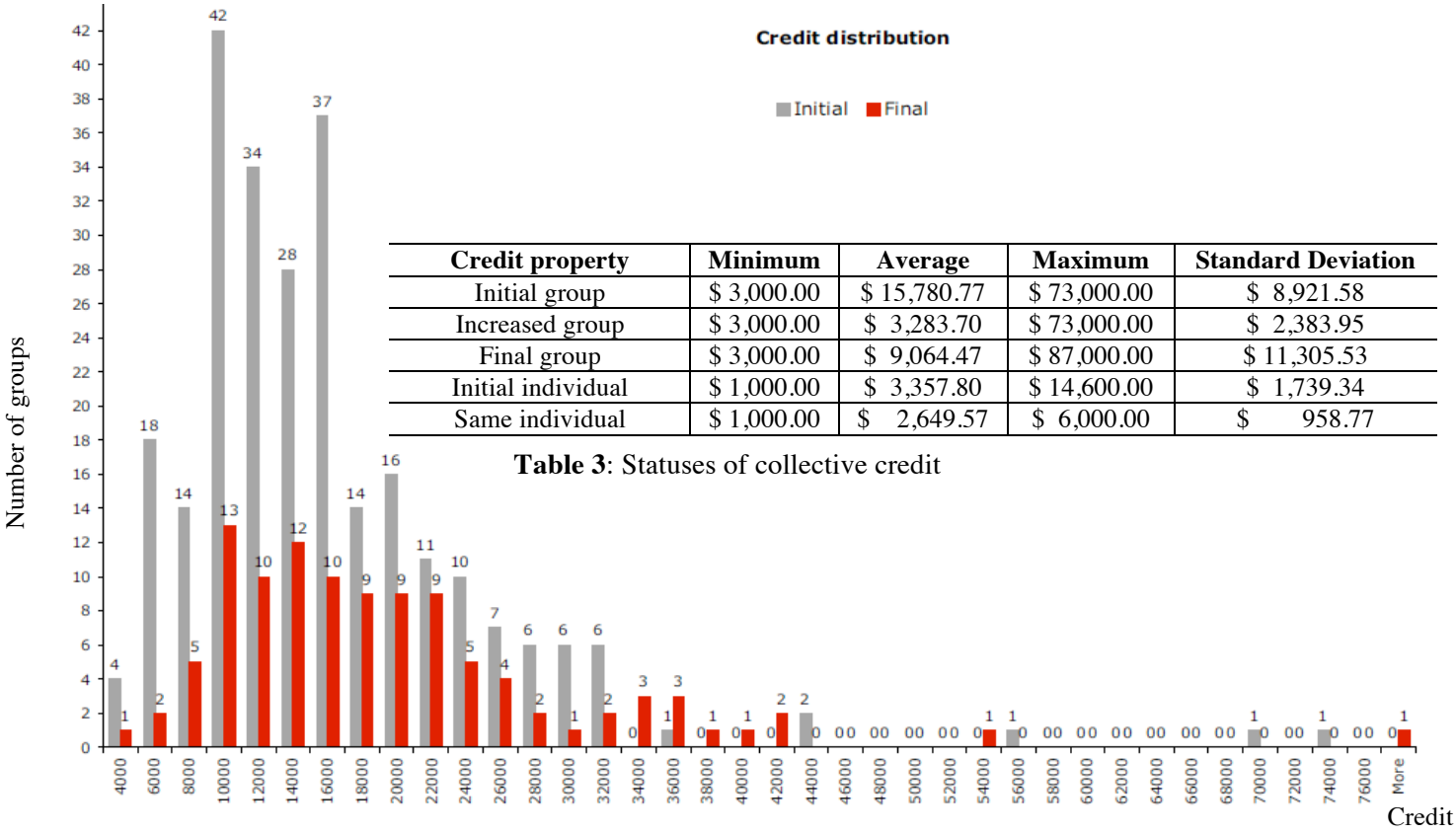


Figure 9: Percentages of diseases that affect defaulters

Table 3 and 4 next synthesises the general state of all credit properties analysed during the fieldwork, both in individual and group terms. Individual credit (Figure 13 and Table 4, page 7) has considerable differences between their minimal ($500) and maximum ($39,538) values, along with standard deviation of $8,422.52. This suggests that some of the interviewed clients have worked with the MFI for years, whilst others have just started. Consequentially, groups also show great variations (minimum $3,000 and maximum $87,000), but the standard deviation should not necessarily be understood as a high value as groups have different numbers of participants. Thus, it is important to interpret this data taking into account the existing variations depicted in Figure 10 and that groups vary between 3 to 7 members (Figure 1 a). The increased value of credit group reflects, in the lower area, how new groups tend to evolve in a rather uniform manner, whereas experienced groups on the opposite side have progressed very differently. The latter ones are responsible for the relatively high standard deviation value ($2,383.95). Groups with the same credit distribution of individual credit had the most regular changes. The data shows that between $1.000 and $6.000, groups tend to evolve in similar ways, as their standard deviation ($958.77) is low when compared to the lowest individual credit ($500). Figure 10 also shows that managing collective credit higher than $18.000 is rather unusual. The proportion of groups that work



Credit property	Minimum	Average	Maximum	Standard Deviation
Initial group	$ 3,000.00	$ 15,780.77	$ 73,000.00	$ 8,921.58
Increased group	$ 3,000.00	$ 3,283.70	$ 73,000.00	$ 2,383.95
Final group	$ 3,000.00	$ 9,064.47	$ 87,000.00	$ 11,305.53
Initial individual	$ 1,000.00	$ 3,357.80	$ 14,600.00	$ 1,739.34
Same individual	$ 1,000.00	$ 2,649.57	$ 6,000.00	$ 958.77

Table 3: Statuses of collective credit

Figure 10: Distribution of group credit

with high amounts of credit is scattered until the top group, which manages more than $87000. These findings are somewhat expected given that these amounts are considered high for microfinance. There are no groups in Figure 10 managing credit between $46000 and $52000, $58000 and $68000, $72000 and $76000. Groups with high credits have more final than initial liquidity. This observation simply means that interviewed groups operating with larger amounts of money are investing MFI credit in their already successful business. Yet one should bear in mind, as discussed on page 1, that many groups no longer exist. Figure 11 shows that initial credits higher than $16000 are gradually less frequent, whilst most values concentrate between $10000 and $15000 are somewhat close to the average mentioned in Table 3 ($15,780.77). The final standard deviation is high ($11,305.53), so it is important to consider that proportionally there are few groups with credit higher than the initial or final averages. To compare credit and debt values with their respective standard deviations, Figure 13 on page 17 illustrates the distributions of all individual and collective relevant averages.

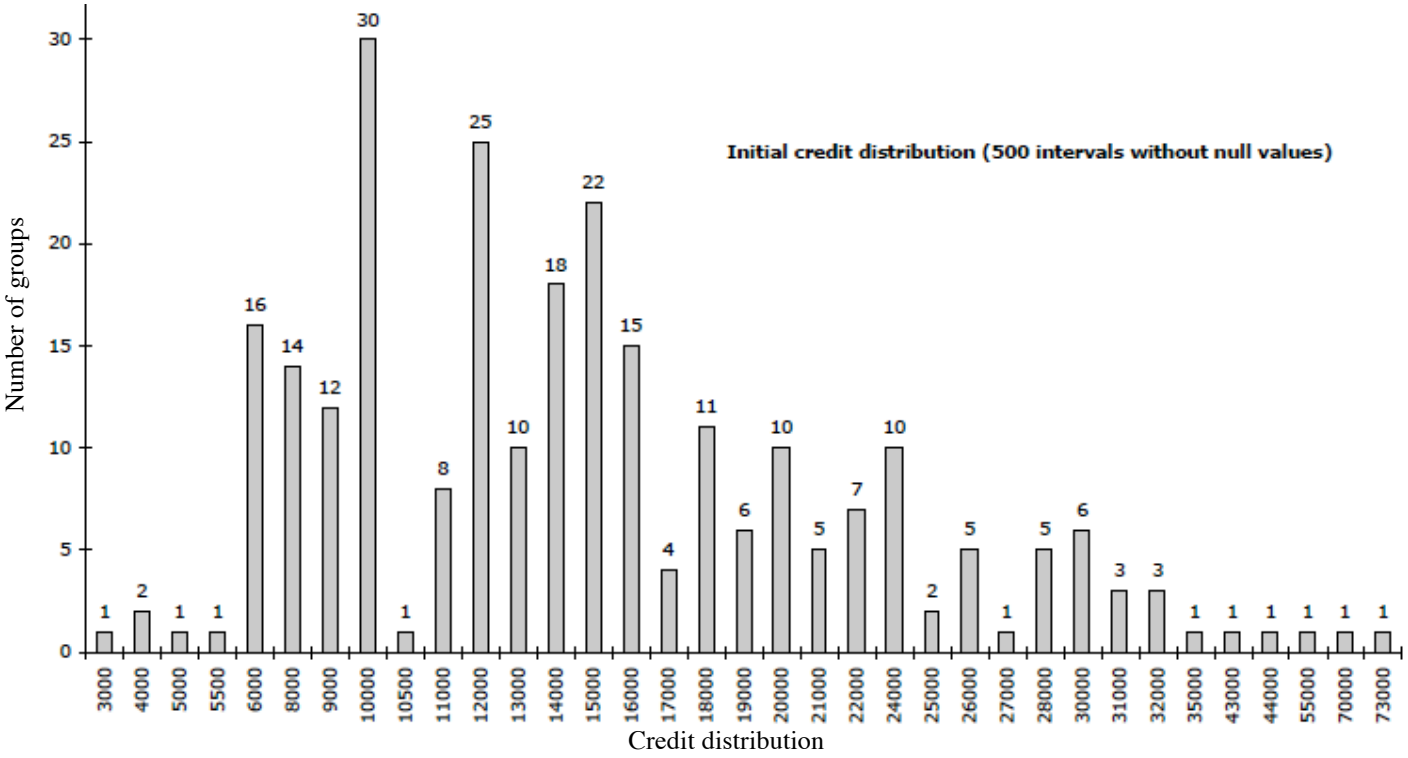


Figure 11: Average of initial collective credits received by interviewed groups

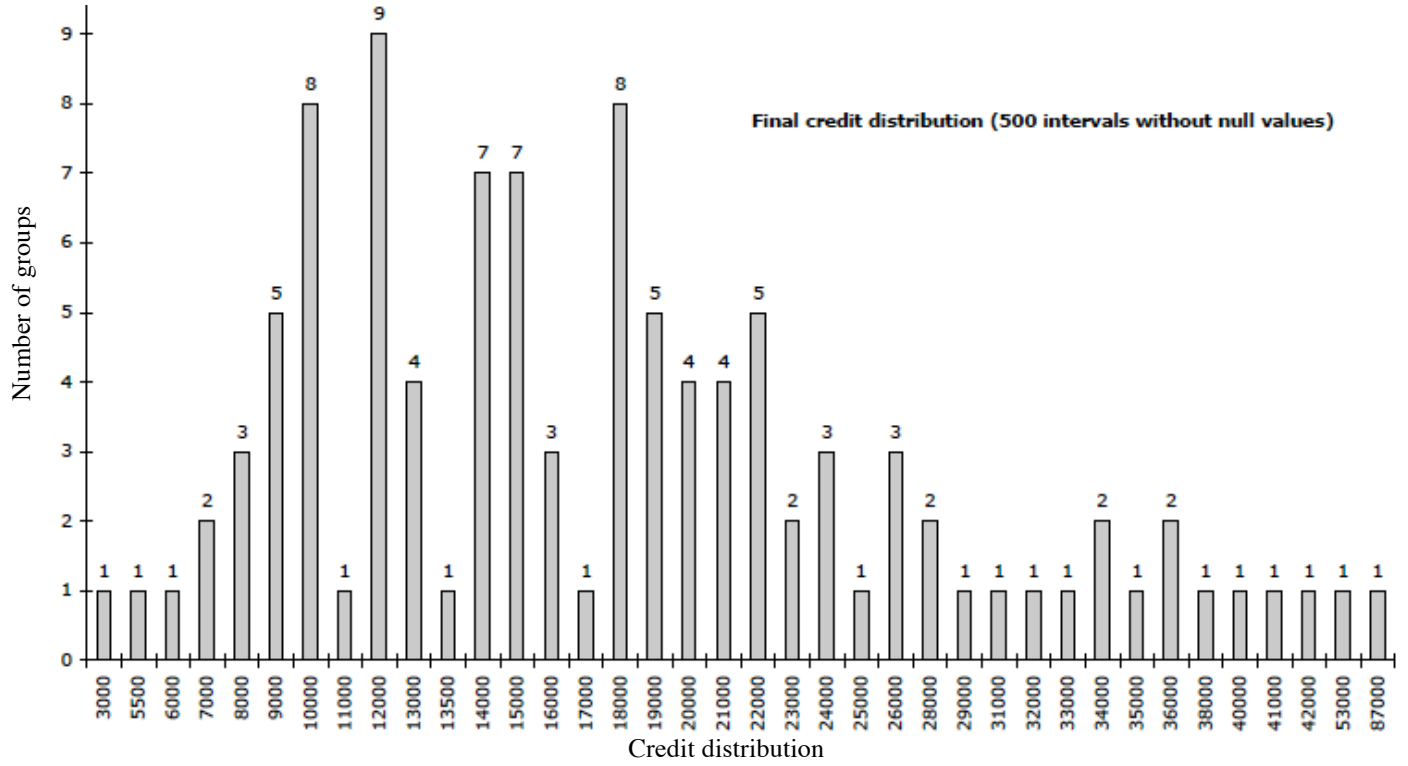


Figure 12: Average of final collective credits received by interviewed groups

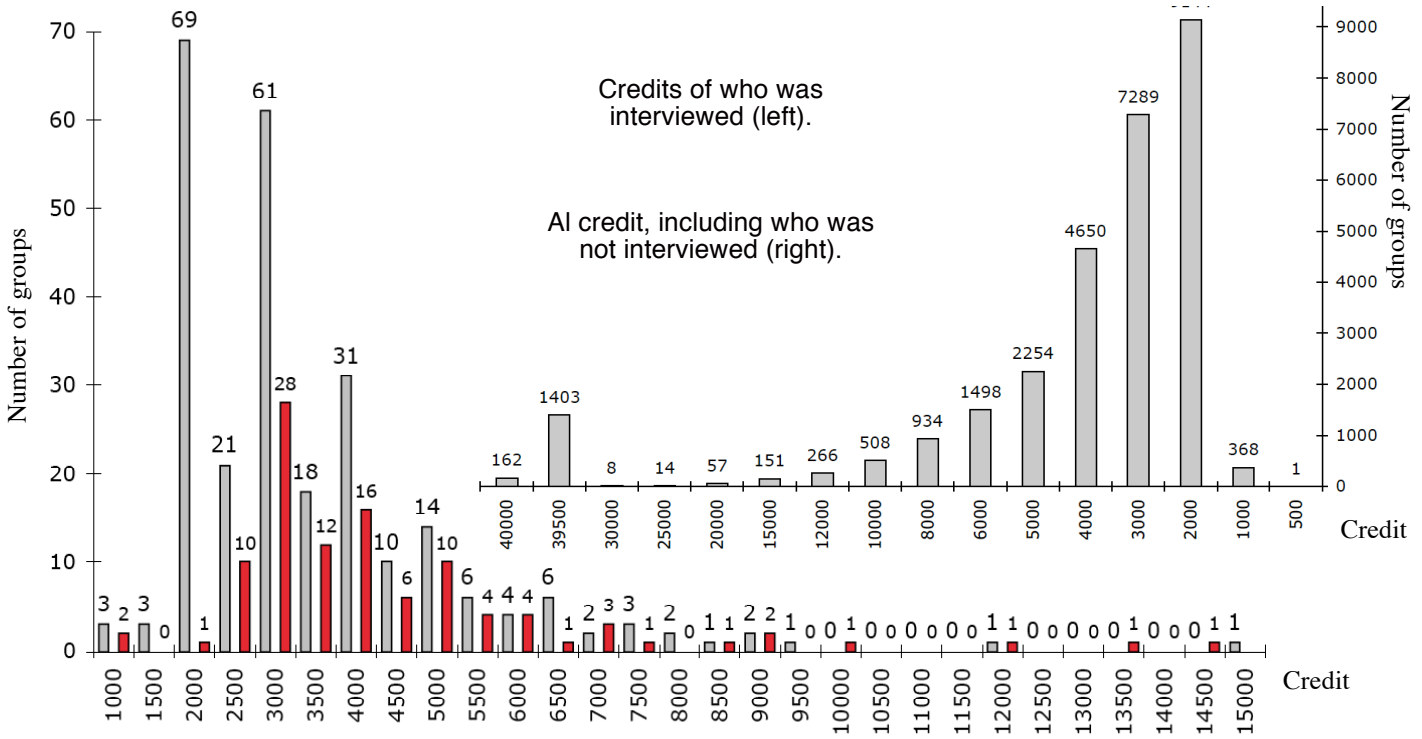


Figure 13: Distribution of average individual final (red) and initial (grey) analysed credits

In Figure 13 one can see that initial individual credits mainly concentrates on between $2000 and $3000. Immediately after $4000 appears and then there are only very few people that received higher instalments. The fact that very few clients have initial or final credit between the minimum values of $500 and $1500 is testimony that the vast majority of interviewed clients in this research are experienced with the MFI in question. It would be interesting to analyse in more detail the circumstances of the few clients with high individual credits, as these are precisely the ones who have a better potential to administer more money and so can easily leave the MFI in search of other financial institutions. That is important, as it is known that entrepreneur clients have difficulties finding other people with comparable credit to work together in their businesses. Table 4 show the properties of available credit in studied financial centres, including data of those who were not interviewed.

Credit properties	Minimum	Average	Maximum	Standard deviation
All individuals	$ 500.00	$ 5,600.04	$ 39,538.00	$ 8,422.52
Interviewed individual (initial)	$ 1,000.00	$ 3,357.80	$ 14,600.00	$ 1,739.34
Interviewed individual (final)	$ 1,000.00	$ 4,194.91	$ 14,500.00	$ 2,210.25

Table 4: Credit of all 600 interviewed clients and the remaining 27507 credits of non-interviewed clients

The main observations about Figure 14 (a) and (b) are: (I) stable groups (group=) frequently reduced debts (debts-), (II) stable groups that kept dept have not yet completed their credit cycles, (III) groups that reduced (group-) frequently increased their debts (debt+), but there are also many that increased credit (credit+), (IV) the majority of groups are stable (group= & credit=) and, as expected, increased their credits (credit+).

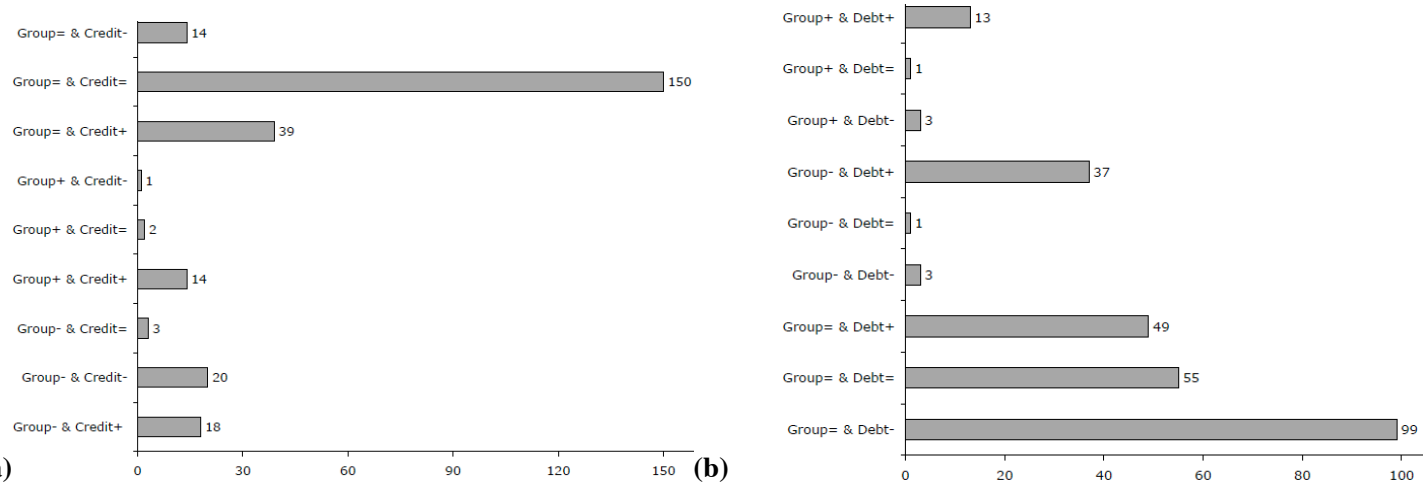
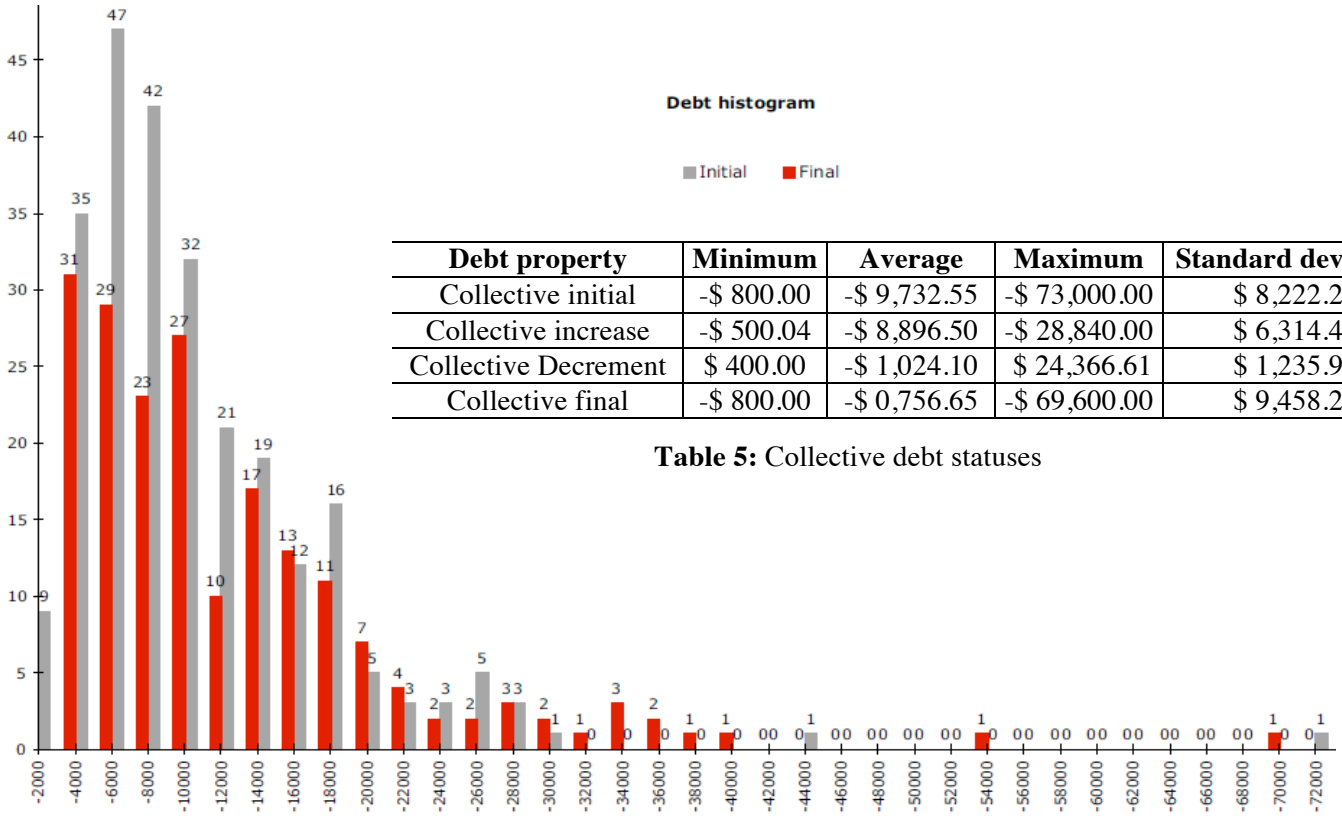


Figure 14: Statuses of groups that changed according to their **(a)** credit evolution and **(b)** debts



Debt property	Minimum	Average	Maximum	Standard deviation
Collective initial	-$ 800.00	-$ 9,732.55	-$ 73,000.00	$ 8,222.29
Collective increase	-$ 500.04	-$ 8,896.50	-$ 28,840.00	$ 6,314.44
Collective Decrement	$ 400.00	-$ 1,024.10	$ 24,366.61	$ 1,235.96
Collective final	-$ 800.00	-$ 0,756.65	-$ 69,600.00	$ 9,458.25

Table 5: Collective debt statuses

Figure 15: Distribution of individual debts

There is no information on individual debt, as these are not registered in the MFI database. Thus Figure 15 and Table 5 only contain collective data about debts. Defaulters' justifications have only been, throughout the fieldwork, annotated on paper by the credit advisors, using a form for each group that monitors quotas per credit cycle. Despite difficult retrieval of this data, which has been filled in by hand would be possible via Optical Character Recognition scanners, but it would not contribute to better understanding the organizational dynamics of groups. This happens as only defaulting events that generated MFI fines have been registered. There are no references as to whether groups have decided to sanction (fine) defaulters. Albeit most of the credit advisors were aware of this group-level process, the MFI has yet no system in place to record this important information. A recommendation for this to be incorporated in their new planned information system has been made. Finally, Figure 16 below shows how the properties of individual and collective credits compare with the properties of collective debts during this fieldwork.

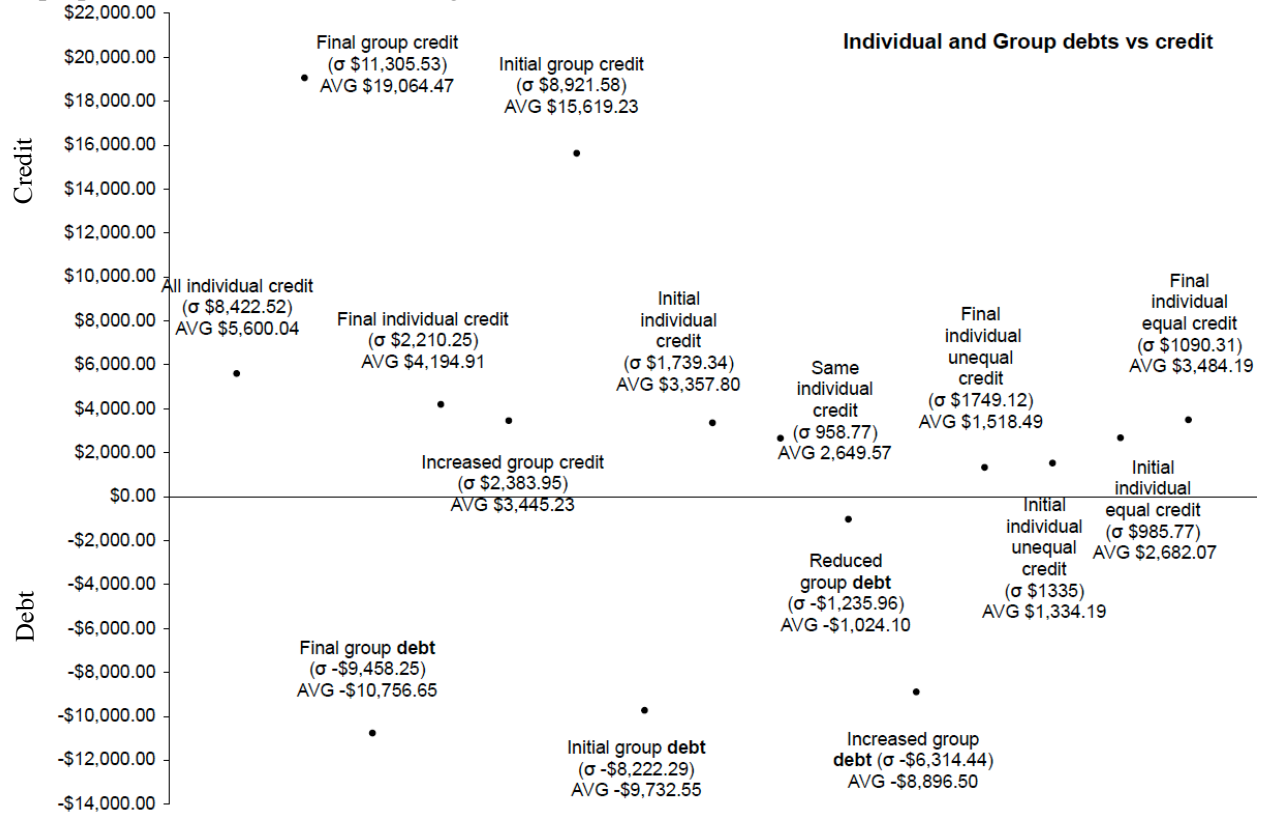


Figure 16: Distribution of credit and debt, both individual and collective

7.4 Appendix IV: Third Fieldwork Report

3rd Fieldwork Report on the 3rd questionnaire to credit officers (July 2nd 2009)

Pablo Lucas, Centre for Policy Modelling (CFPM), Manchester, England, pablo@cfpm.org

1 Introduction

This report synthesises results from the last questionnaire to credit officers. Questions were designed to double check doubts derived from analysing previous data and findings. According to our publishing agreement, the microfinance institution (MFI) identity and location is omitted. Next sections contain interpretations of the 24 credit officer's answers collected online. This time fewer people participated, as despite increasing the number of employees, some officers no longer work for the same MFI. I would like to thank the MFI director and their team for supporting this study.

2 Data analysis

The questionnaire analysed in this report contained ten questions. Figure 1 below illustrates the proportions and absolute number of answers in the three text fields available for credit officers to fill in their answers on expelling causes, in no particular order. The most frequent causes stated were "defaults", "lack of cooperation", "missed meetings" and "personal problems". Other answers included "high quotas", "other debts" and "late payments". Interestingly responses are largely concentrated on endogenous group aspects, whilst the less frequent ones focus mainly on exogenous group issues. This is relevant as microcredit methodology can be directly influenced by bottom-up social conventions that evolve at the group-level organisation. Thus understanding what causes infrequent, but very disruptive, events such as expelling is crucial. These answers provide further confirmation of what was indicated since the fieldwork started: successful group strategies focus on ousting who is not cooperative.

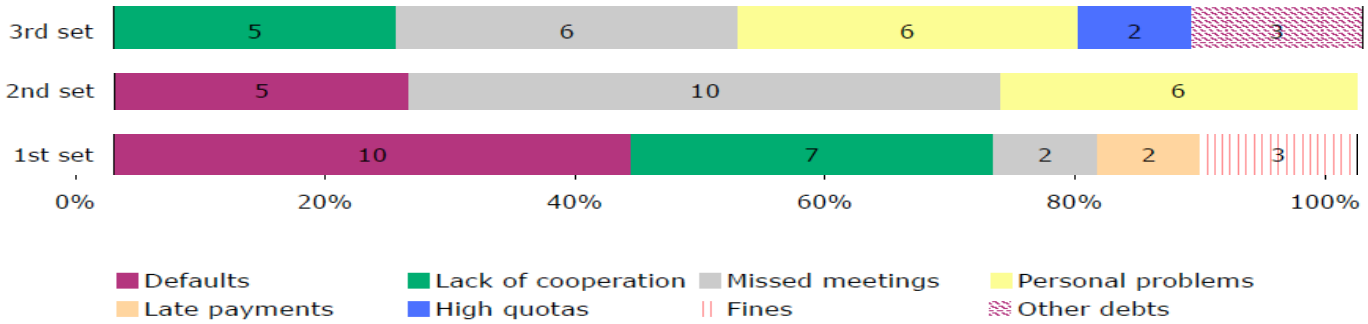


Figure 1: What are the most frequent expelling causes?

Figure 2 shows that most credit officers agree with two of the strongest indications reckoned during the fieldwork. This includes observations that there are: (a) usually more family members in rural groups and (b) that most MFI clients already had previous experience with some other form of saving or lending money amongst themselves. These two highlighted aspects are consistent with usual trends published in microfinance and third-sector literature.

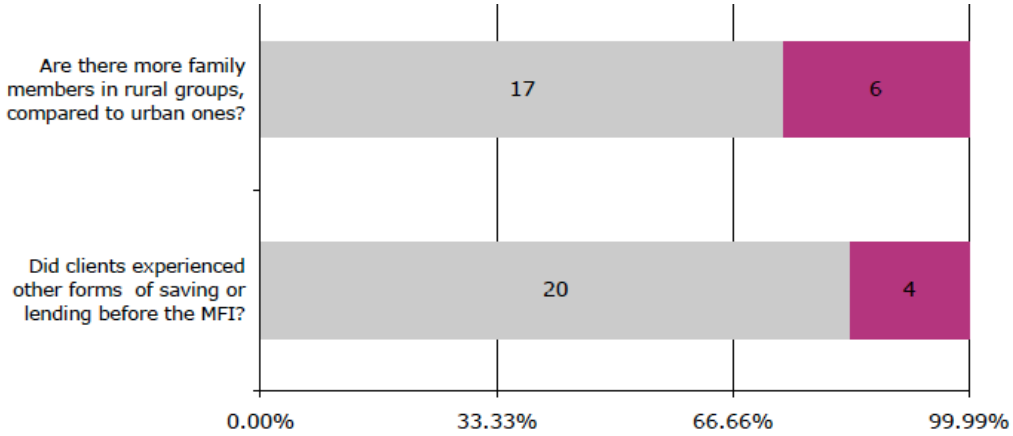


Figure 2: Credit officers' observations on groups experience and those formed by family members

Figure 3 illustrates credit officers' understanding of some important social and financial aspects of their monitored groups. It includes a slightly counter-intuitive finding: most rural clients are trading without intermediaries. This is unexpected, as during fieldwork, most observed rural groups could not trade directly with their customers due to transportation limitations. This new result perhaps reflects changes in the circumstances where interviewees work.

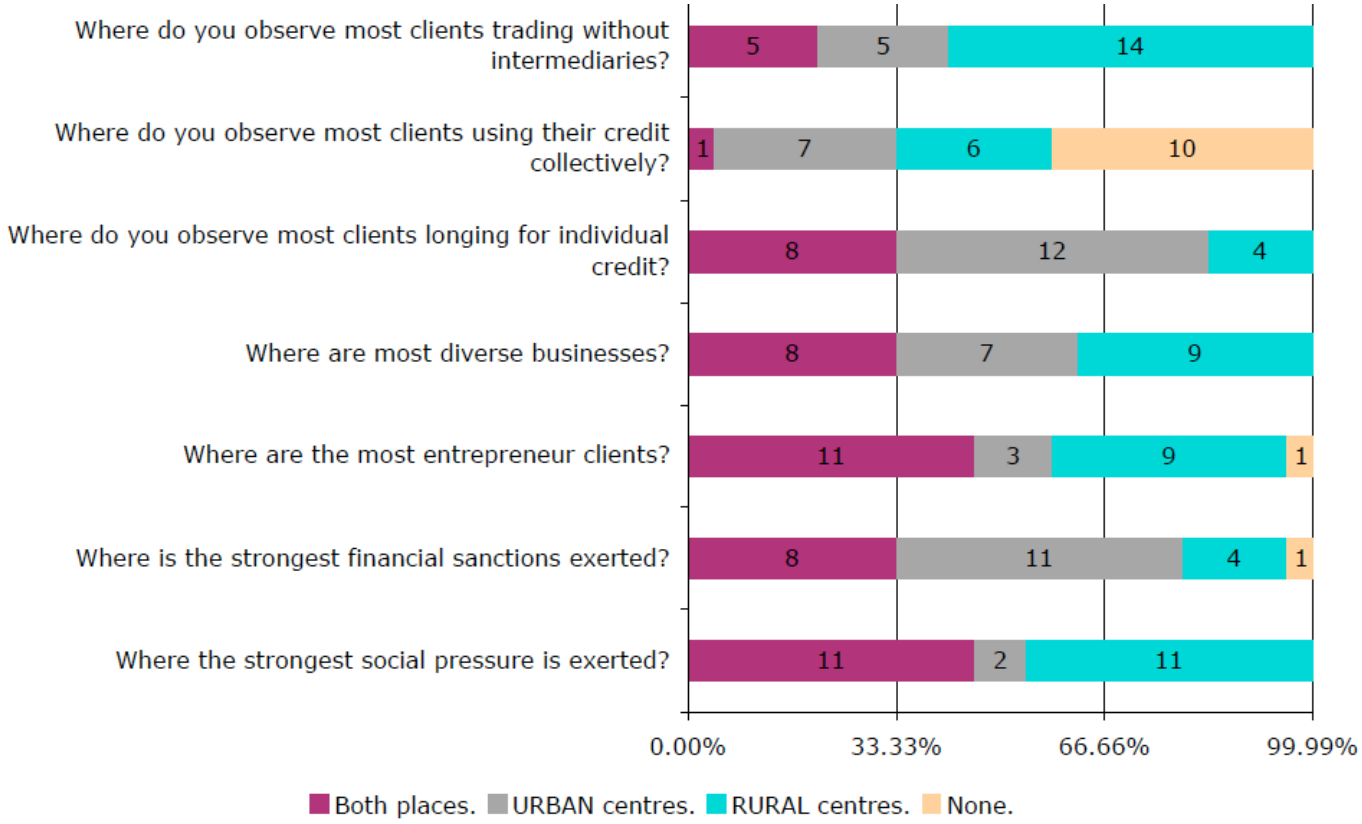


Figure 3: A variety of issues surrounding client's trade and group dynamics

A large proportion of clients seemingly do not invest credit collectively, yet there are sizeable results both on rural and urban ones that do. Demand for individual credit is apparently more evident amongst urban clients. However the difference regarding answers including rural clients is not significant. Similar findings can be seen in terms of business diversification. Entrepreneurship is evident amongst rural centres. Nevertheless data suggests that differences observed by credit officers are not dependent on location, as most answers indicated that there are many strong entrepreneurs both in rural and urban groups. Financial sanctions were highlighted as most intense in urban centres; yet again this dataset does not allow a responsible interpretation beyond this statement. The last question in the figure regarding social pressure, suggests that both urban and rural groups employ significant peer monitoring.

3 Final considerations

This short report is meant simply to serve as a complimentary material to the other two extensive reports compiled on the social norms and financial aspects of all 600 surveyed microfinance clients. No more surveys are planned for this study, as much has changed since the core activities of fieldwork between September 2007 and May 2008, involving the analysis of all their 5 microfinance databases and 3 surveys completed from that period till July 2009.

Some findings have been relevant both to the MFI policy-makers and academically, as there is evidence that the evolutionary social processes regarding the self-organisation of microfinance groups are still occurring amongst clients of the same MFI. All data from this project has been analysed, thus a future final publication will contain a more in-depth discussion on the relevant findings and research impact. As previously discussed with the MFI director, I welcome feedback on all publications and results from the simulation model based on this work.

7.5 Appendix V: Usage of Agent-Based Models

The poster annexed on the next page has been presented following an invitation to participate in the 2009 Rich Cognitive Models for Policy Design and Simulation Workshop, held in Leiden (Netherlands). For a discussion on the aspects mentioned in there, refer to Section 3.2.2: "Challenges in Simulating Social Phenomena with ABM" (page 61) and Section 4.3: "Evidence-Driven Approach to Modelling (EDAM)" (page 86).

Usefulness of Social Simulation To Stakeholders

Pablo Lucas, Scott Moss
{pablo,scott}@cfpm.org

Introduction

This poster is dedicated to the discussion of **methodological issues** of developing social simulation research that ought to provide **useful results beyond theory** to stakeholders.

I.e. how can social simulation, or other products of an evidence-driven agent-based modelling approach, be useful insofar as fieldwork findings ?

Analysis of evidence is increasingly being used to guide **understanding** of social phenomena and processes of **simulation design** and **validation**.

Statistically relevant data on social phenomena can be problematic as often is: **(a)** non-existent, **(b)** unavailable due to privacy issues agreements or **(c)** when at hand, datasets are typically outdated.

Social simulation *status quo* is **not yet useful** in practice to non-academic stakeholders, mainly due to **validation problems + high speculative risk** involved in taking onboard results obtained in these models for **policy making purposes**.

Social simulations vs. Games

Research network **SageForLearning.ca** has set clear boundaries between intellectual games and simulations.

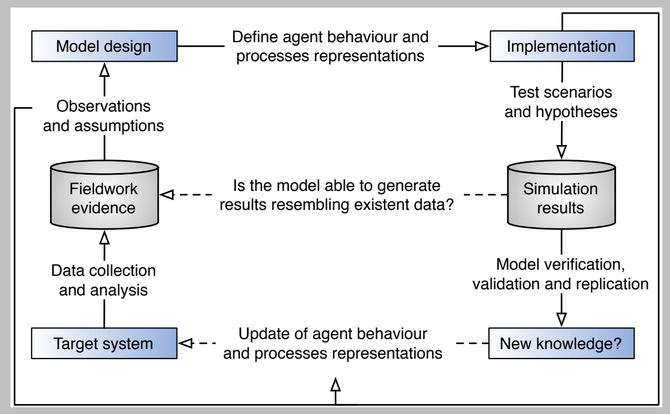
Intellectual games: static rules for resolving conflicts, players as decision makers, competing cooperation strategies and goals associated with fictional characters.

Simulations: limited representation of a phenomenon that ***necessarily*** mediates acquisition of new knowledge about the actual social system **via simulations**.

Acquiring knowledge about models is not equivalent!

Useful social simulation requires evidence, otherwise one would not bother with **credible and plausible justifications** for modelling decisions and obtained results.

Evidence-driven modelling life-cycle



Development phases

Target system = actual social phenomenon from where fieldwork data should be collected and analysed.

Observations and assumptions are selected from the target system for analysis and plausibility check.

It is critical to differentiate what is relevant to model from what is needed to understand a given context.

Representation and implementation of available data is a personal choice usually based on the technical advantages of using procedural, object-oriented or declarative paradigms.

Simulation data is analysed as to whether it resembles features found in the target system and as to whether findings can help shed new light on the real social phenomena.

Still unclear how simulations can provide pragmatic useful findings as fieldwork reports can be, both to guide stakeholders and modellers.

If simulation results systematically diverge from what has been observed in the target system, modellers usually need to reconsider implementation, data representation and the specified parameters.

Characterised projects so far: 6 evidence-driven models, including an interview with at least one modeller per case study, regarding the usefulness of simulation results to involved stakeholders.

None had examples of pragmatic contributions to stakeholders provided via interpreting simulation results.

Deficient research methodologies, combined with developed models that are neither games nor useful simulations per se, contribute to the lack of confidence in stakeholders considering results.

This does not imply that social simulation researchers should see stakeholders as clients, but simply highlights how little this type of research has contributed beyond academic theories.

Ought to achieve

Stakeholders are not interested whatsoever in how social phenomena is modelled, but rather in **what are the pragmatic contributions from this research process or simulation tool**.

Most findings taken into practical account derive from fieldwork findings, not simulations.

There is a **pressing need** for developing social simulation research that is **useful to academics *and* stakeholders**.

Persisting problems include:

(a) How can simulation results providing data beyond comparable existing evidence mediate acquisition of new knowledge about a certain social phenomenon?

(b) Which practical contributions social simulations can provide to stakeholders apart from illustrating hypotheses that are only verifiable with more data?

Bibliography

Bruce Edmonds, Scott Moss, (2005) From KISS to KIDS – an 'anti-simplistic' modelling approach. In P. Davidsson et al. (Ed.): Multi Agent Based Simulation 2004. Springer, lecture Notes in Artificial Intelligence, 3415:130–144.

Scott Moss (2008) Alternative Approaches to the Empirical Validation of Agent-Based Models. Journal of Artificial Societies and Social Simulation vol. 11, no. 1 5.

Scott Moss, Bruce Edmonds (2005) Sociology and Simulation: Statistical and Qualitative Cross-Validation. American Journal of Sociology, 110(4), pp. 1095-1131.

Ian Foster (1995) Designing and Building Parallel Programs: Concepts and Tools for Parallel Software Engineering. Addison-Wesley Longman Publishing Co., Inc. Available at: www-unix.mcs.anl.gov/dbpp , 3.4 Scalability Analysis

Joshua M. Epstein (2008). 'Why Model?'. Journal of Artificial Societies and Social Simulation 11(4)12 http://jasss.soc.surrey.ac.uk/11/4/12.html

Manchester Metropolitan University
Centre For Policy Modelling
Sixth Framework Programme,Information Society Technologies. EMIL, Emergence In the Loop: Simulating the two way dynamics of norm innovation. EC Contract No. 033841
emil.istc.cnr.it kaiowas.no-ip.org
LaTeX2e

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7.6 Appendix VI: the Agent-Based Model

```
1  ; Simulation Model of Solidarity Groups with new credit. Licensed under GPL V2.
2  ; Pablo Lucas. pablo@cfpm.org ;  Copyleft updates by the author on:
3  ; Obs.: Minor changes have been made between dates, but not all was logged.
4  ;
5  ; 15 July 2009
6  ; - plot what happened with the order of problems;
7  ; - reset counters of all meetings problems;
8  ;
9  ; 10 June 09
10 ; - graphs update as the simulation progress, instead of all at the end;
11 ; - POTENTIAL: plot and calculate quotas incrementally towards the full
12 ;    payment, with interest rates, as the model does not yet take that into
13 ;    account in deciding what agents do with defaulters due to lack of evidence;
14 ; - Fixed a bug when maximum and minimum debts are set equal;
15 ; - shuffled aux-OrderedGroup (order to process individual decisions);
16 ; - updated applet with sixth graph;
17 ; - added graph to know the order of problems' recurrence
18 ;
19 ; 8 June 09
20 ; - corrected a bug to only allow total bad investors and unprofitable be less
21 ;   than the group size, otherwise the group will only face problems and nobody
22 ;   would be able to take decisions to overcome their circumstances;
23 ; - created auxiliary lists to deal with the order of different final outcomes;
24 ; - set plots of simulation outcomes update whilst the whole run is being
25 ;   executed, as final bar graphs sometimes aren't enough clear;
26 ; - made only update total group outcomes, elapsed time and individual debts;
27 ; - some graphs update  along with execution, as the others need ordering data
28 ;    at the end of all for then to be plotted to help interpreting results;
29 ; - added in init a control about writing to a file or not, boolean WriteToFile;
30 ;
31 ; 5 June 09
32 ; - made http://cfpm.org/~pablo/ABSS_MC/ test model available to the MFI board;
33 ; - had a meeting with them and on June 7th, a HowTo was presented to them;
34 ;
35 ; 4 June 09
36 ; - ordered data output of aux-Plot and graph using the structure created
```

```
37 ; - 3 types of results are written separately in a file to help with graphing
38 ; - logging all summarised data, regardless whether Plots are on or off
39 ;
40 ;
41 ; 3 June 09
42 ; - ordered CSV output so graphs can be understood, sections zoomed and
43 ;   classified; debts and elapsed time kept on in runs with enabled Plots;
44 ;
45 ; 2 June 09
46 ; - added switch control as to weather data is graphed or not;
47 ; - corrected equal groups summary, as data wasn't in aux-summary list;
48 ;
49 ; 27 May 09
50 ; - Logged simplified events as shown in graphs and started running
51 ;   an extensive sensitivity  analysis of the realistic parameters space;
52 ; - THE main difference between groups with more acceptable events than
53 ;    unacceptable ones is the consistent higher incidence of supportive events,
54 ;    such as group visits, losses being covered, and less expelling (taking
55 ;    into consideration the number of losses and missed meetings).
56 ; - equal group events plot only uses lines as those occur far less often,
57 ;   so analysis of how simulations with similar results compare;
58 ;
59 ; 22 May 09
60 ; - changed nomenclature from positive to acceptable and negative to unacceptable
61 ; - put online an applet to allow stakeholders and researchers testing it;
62 ;
63 ; 21 May 09
64 ; - changed acceptable events as the subject being sick and evaluator tolerant,
65 ;    and unacceptable as not being tolerant only;
66 ; - POTENTIAL: test if tolerant results are more likely in rural groups;
67 ; - deleted DiseaseAffects "Multiple clients" as that creates a unacceptable
68 ;   reinforcement of acceptable events, thus also removed AffectUnique switch.
69 ; - created graphs using the same events, both for groups with more acceptable,
70 ;   unacceptable and equal number of these events.;
71 ; - unacceptable and acceptable group events plots uses lines, bars and dots,
72 ;    as otherwise the final result can become too polluted (busy with data).;
```

```
73  ; - added plots of unacceptable, equal and acceptable events, which helped to
74  ;    confirm that acceptable events only increase when diseases are introduced;
75  ; - removed plotting recurrent events when nothing happens as pollutes graph
76  ;   unnecessarily. I.e., only show things when there is some useful data in it;
77  ; - removed aux-TotalNoLoss as it pollutes all graphs, fixed individual debts
78  ;    scatterplot and empty MeetingTrack entries;
79  ; - removed aux-TotalPaidOnTime, aux-TotalNoLoss, aux-TotalAvoidLoss,
80  ;   aux-TotalMissedMeetings, aux-TotalMissedPayments and aux-TotalMyLoss
81  ;   aux-TotalPaidOnTime from acceptable / unacceptable graphs as these
82  ;   generate too many events that are not useful to analyse many simulations;
83  ;   instead some of these events have been grouped to ease interpretation;
84  ; - integrated both types of fines (mfi and group into one property in plots),
85  ;   same thing for total and partial support, as otherwise these events would
86  ;   generally not be visible as these occur considerably less than others;
87  ; 11 May 09
88  ; - fixed a various conflicting conditions when configuring probable defaulters;
89  ; - this model is only useful when defaulting influences are included;
90  ; - counted only once occurrence of aux-PossibleProblematicMeetings;
91  ; - set MFI-Adviser MeetingTrack right whenever MFI_Fines occur;
92  ;
93  ; 10 May 09
94  ; - set length of for multiple sick agents as the following: ; < round
95  ;   (Disease-Incidence * MFI- Group / 100), instead of a random MFI-Group;
96  ;
97  ; 09 May 09
98  ; - controlled various erroneous configurations in having multiple potential
99  ;   defaulters, AffectUnique affects how the same clients may be chosen;
100 ; - replaced aux-ProblematicMeetings with aux-PossibleProblematicMeetings;
101 ;
102 ; 08 May 09
103 ; - separated setup-defaulting-investment-influence, setup-defaulting-
104 ;   disease-influence and setup-defaulting-unprofitable-influence . So these
105 ;   events can be configured separately, if necessary as in the cases of
106 ;    multiple clients possibly incurring defaults in the same meeting;
107 ;
108 ; 29 April 09
```

```
109 ; - fixed output of languages, business and location, plus many technical
110 ;     details in the code have been rewritten for better legibility;
111 ; - kept last eventcount within the same output column;
112 ; - POTENTIAL: check effects of > 50 and < 50 with fixed random-seed;
113 ;
114 ; 28 April 2009
115 ; - total equal, unacceptable and acceptable groups after all cycles;
116 ; - fixed  MFI Fine, Group Fine, Group Loss all empty in the end;
117 ; - fixed bug in ( (item 1 (item 0 Tolerance-of (item 0 aux-Fine) ) );
118 ;   = "tolerant"), substituted ifelse ( (item 0 Language-of (item 1
119 ;   aux-Problematic)) = (item 0 Language-of (item 0 aux-Fine)) ) for
120 ;   actually checking the proper individual tolerance criteria;
121 ; - commented same business type as a criteria ifelse ( (item 2 Business-of
122 ;   (item 1 aux-Problematic)) =  (item 2 Business-of (item 0 aux-Fine)) ) ;
123 ;
124 ; 27 April 2009
125 ; - added commentaries on the information tab, standardised source comments;
126 ; - code partially rewritten, removed TotalSick, meeting-Unprofitable-Agents,
127 ;   aux-SickEvents, TotalBadInvestors, aux-MultipleSickAgents, meeting-
128 ;   BadInvestor-Agents, TotalUnprofitable and TotalMeetingSickAgents;
129 ; - sorted logging all acceptable, unacceptable and simulation counters, with
130 ;     all individual and collective data for acceptable or unacceptable results;
131 ; - fixed logging of last simulation summary, and merged acceptable, equal
132 ;   and unacceptable groups in the same final log to ease analysis;
133 ; - moved #undesirables beside #desirables in the log, to ease graphing;
134 ;
135 ; 24 April 2009
136 ; - commented more on the information tab,  polished lots of bits in code;
137 ; - reformatted almost everything for the output file, mainly by dealing how
138 ;   to log all that matters separately: aux-Summary, aux-TotalMissedMeetings;
139 ;
140 ; 23 April 2009
141 ; - fixed My_Loss in sickness isn't leading to other actions;
142 ; - fixed debts order and logging of mfi / group fines, both for rural and
143 ;   urban groups, set cohesion to SAME TYPE business,  language and sickness;
144 ; - removed indifference in tolerance, as that could simply become intolerant;
```

```
145 ; - fixed support (limit/tolerance for covering losses for non-first timers);
146 ; - created different agent types: clients and advisor, then added counters
147 ;   for unacceptable and acceptable endorsements per meeting and cycle;
148 ; - set and logged the criteria of succeeding and failing groups;
149 ; - fixed length of aux-PossileRuralBusiness and random-seed ease replication;
150 ;
151 ; 22 April 2009
152 ; - fixed EMPTY MEETINGTRACK display, COVER_Loss and VOTE_Expel are
153 ;    no longer repeating for same agent in certain events and meetings;
154 ; - fixed order of problems logging, zombie agents (dead ones that appeared
155 ;   in the next simulation cycle), added detailed headers of iterative runs;
156 ; - acceptable events to first timers will only happen when an agent is sick;
157 ; - fixed length of SUPPORT and NO_SUPPORT by adding missing appropriate /
158 ;   respective debts for GROUP_FINE, MFI_FINE and Cover_Loss ;
159 ;
160 ; 21 April 2009
161 ; - replaced numerical tolerance with binary concept: intolerant or tolerant;
162 ; - removed likelihood, managed debt and include it in the output, then checked
163 ;   that the log is correct, fixed header information and designed a way for
164 ;   disease to affect the whole credit cycle. fixed endorsements between agents.
165 ;   logged languages, business and location, updated group debts after events;
166 ;
167 ; 12 April 2009
168 ; - fixed repeated events by only using aux-Fine agent in the last iteration;
169 ; - changed labels on logging events, added event of who missed meeting
170 ;    and payment. defined MFI fine as interest rate on the calculated debt,
171 ;    group fine as half of that debt; the formal is more severe than informal;
172 ; - removed group number as simulation will only make sense for one group
173 ; - removed relatives, so if group is rural it is assumed they are most likely
174 ;   to be family members, otherwise it is likely they are urban and neighbours;
175 ;
176 ; 11 April 2009
177 ; - reviewed and fixed events of who missed meeting, but not payment, events
178 ;    are given after ALL problems, set events of first timers and events of
179 ;    those who already have some individual history about the whole group;
180 ;
```

```
181 ;
182 ;10 April 2009
183 ; - log all history during the credit cycle, fixed Unprofitable clients logs;
184 ;
185 ; 9 April 2009
186 ; - changed descriptions in revised code, fixed agent 3 always returning
187 ;   Tolerance below 0, and others higher than 100 in a normal distribution;
188 ; - aux-TotalGroupDebt is logged according to iterative runs, reduced interest
189 ;  rate range from 0 to 3, configured total group debt with interest rate;
190 ; - set language differentiation by location, rural and urban,  fixed group
191 ;   debt with and without interest rates and ProblemsOrder;
192 ; - set agents flags IsSick, IsUnprofitable and IsBadInvestor;
193 ; - set Defaulted, MissedMeeting for sickness, MeetingTrack for diseases,
194 ;   badinvestors and unprofitable, fixed non appearing IsSick where it should;
195 ; - did a person misses a meeting / payment when: is a bad investor (9%), is
196 ;   unprofitable (11%) or is hit by disease (19%);
197 ;
198 ; 26 March 2009
199 ; - changed disposition for tolerance, thus: removed [un]willingness issues
200 ;   Tolerance ;depending on these values, they would endorse group
201 ;   members desirably or undesirably; fixed various problems with log
202 ;   output issues + aux-PossibleProblematicMeetings (Bad-Investors, Unprofitable
203 ;   -Clients and Diseases);- fixed set non-unique affected clients;
204 ; - fixed relatives are minimally a pair, unprofitable and bad investors unique;
205 ;
206 ;
207 ; 17 Mar 09
208 ; - fixed minor issues in Disease-Incidence,  did a setup-defaulting-influences
209 ;   for diseases, unprofitability and bad investors;
210 ; - ProblemNature affecting unique agents are defined in setup-defaulting-
211 ;   influences, made Unprofitability become Unprofitable-Clients, as Bad-
212 ;   Investors; Disease is calculated as incidence, as there is less evidence
213 ;   about how these occur, otherwise epidemiology would become the focus;
214 ; - multiple number of sick agents calculated uniquely and randomly, otherwise
215 ;   just one is picked; Unique ProblemNature means that for each problem,
216 ;   namely Unprofitable and Bad Investors, there will be unique agents. So
```

```
217 ;    these can involve the same agent being affected by both problems.
218 ; - removed relative and neighbour UNwinlingness and Willingness, substituted
219 ;     these simply for a universal Willingness and UNwinlingness property, as
220 ;    now simulations run only with groups formed either by family or neighbours;
221 ; - removed ProblemsOcurr as needs to set when problems will happen apart
222 ;     from the beginning; like diseases, as presumably nobody would start a group
223 ;     with all being sick;removed Non-sequential options from unique and non-
224 ;     unique ProblemNature as that will be defined by problematicmeetings. that
225 ;     number depend mostly on disease incidence, but the number of problematic
226 ;     agents vary from Bad Investments, Unprofitability and Diseases;
227 ;
228 ;
229 ; 13, 14, 16 March 2009
230 ; - reduced the number of different combinations in the parameter space;
231 ; - added user messages to halt the simulation when configurations are wrong;
232 ; - controlled all Bad-Investors, sequential & unique and non-unique;
233 ;
234 ; 12 March 2009
235 ; - set all clients knowing one Mayan language (rural) and Spanish (urban);
236 ; - fixed various log details: precisions, iterative runs, location, counters,
237 ;     equal credit, aux-TotalGroupDebt, PersonalDebt, QuotaWithInterestRate;
238 ;
239 ; 11 March 2009
240 ; - commented all source code, corrected a number of issues in the numerical
241 ;    options for distributing Tolerance amongst group members (Exponential,
242 ;    Random, Poissan, Gamma and Normal), set equal debts concentrated in
243 ;    33%, according to the most common values found in fieldwork analysis;
244 ;
245 ; 11 February 2009
246 ; - corrected languages issue for rural and urban groups, added Disease
247 ;     Incidence and ProblemsOccur parameters; corrected number of sick
248 ;     agents per cycle; made disease only affect one member per group;
249 ;
250 ; 10 February 2009
251 ; - Corrected parameters according to fieldwork findings; Added Languages,
252 ;    Business, Locations to agents; Random seed in the output, market (urban
```

```
253 ;   or rural); timer, added debt variance and QuotaWithInterestRate repayment;
254 ;
255 ; 20 October 2008
256 ; - Translated everything in this model to English, added new configurations,
257 ;   corrected internal timer; corrected init of the MaxInitialTolerance fixed
258 ;   the SimulationRun, and output issues; wrote 1st Tolerance as part of runs;
259 ;
260 ; 21 October 2008
261 ; - Changed Tolerance init using a random float using a normaldistribution;
262 ;   decimal points, apart from debts, are dealt with a precision of 3;
263 ;
264 ;
265 ;;;;;;;;;;;;;;  GLOBAL VARIABLES AND THOSE FOR THE INTERFACE  ;;;;;;;;;;;;;;;
266 ;
267 ;
268 globals
269 [ ;
270   ; Auxiliary variables regarding agents.
271   ;
272   aux-PossibleLanguages      aux-PossibleLocations
273   aux-PossileRuralBusiness   aux-PossibleUrbanBusiness
274   aux-LoggedEventOrder       aux-TotalGroupDebt
275   ;
276   ; Auxiliary variables regarding simulation runs.
277   ;
278   aux-OutputFile   aux-Repayment   aux-Summary   aux-PlotData
279   aux-PossibleDiseaseEvents       ;number of possible disease events
280   aux-UniqueSickClients           ;control who has been sick (list)
281   aux-UniqueUnprofitable          ;control who can be one
282   aux-UniqueBadInvestors          ;control who can be one
283   aux-OrderedGroup                ;all group members in fixed order
284   aux-PossibleProblematicMeetings  ;how many possible troubled meetings
285
286   ;
287   ; LoggedEvents, unacceptable, TotalUndesirable, MissedMeetings,
288   ; MissedPayments, SickClients, BadInvestors, Unprofitable, MY_Loss,
```

```
289    ; ElapsedTime
290    ;
291    aux-TotalPartialSupport  aux-TotalVoteExpel    aux-TotalMFI_Fine
292    aux-TotalMyLoss          aux-TotalGroupFine    aux-TotalGroupLoss
293    aux-TotalUndesirable
294
295    ;
296    ; Simulation counters
297    ;
298    aux-TotalMissedMeetings  aux-TotalMissedPayments  aux-TotalSickClients
299    aux-TotalBadInvestors    aux-TotalUnprofitable
300
301    ;
302    ; Loggedevents, acceptable, TotalDesirable, LEADER_Visit, GROUP_Visit,
303    ; COVER_Loss + COVERED_Loss, NO_Loss, PaidOnTime, AVOID_Loss,
304    ; ElapsedTime, aux-Summary
305    ;
306    aux-TotalSupport       aux-TotalLeaderVisit  aux-TotalGroupVisit
307    aux-TotalCoverLoss     aux-TotalNoLoss       aux-TotalPaidOnTime
308    aux-TotalDesirable     aux-TotalAvoidLoss
309
310    aux-DisUnpBIn    aux-DisBInUnp    aux-UnpDisBIn          aux-UnpBInDis
311    aux-BInUnpDis    aux-BInDisUnp    aux-ProblemsOrderList
312
313    aux-Run ;to make agents realise where they are in the credit cycle
314    WriteToFile ;boolean to have a version for the applet, and another offline
315  ]
316
317  ;;;;;;;;;;;;;;;;  AGENT TYPES  ;;;;;;;;;;;;;;;;
318  ;
319  ; Just two types, clients and MFI_Adviser.
320  ;
321  breed [ MFI_Clients ]       breed [ MFI_Adviser ]
322  ;
323  ;;;;;;;;;;;;;;;;  INDIVIDUAL VARIABLES  ;;;;;;;;;;;;;;;;
324  ;
```

```
325 MFI_Adviser–own [ MeetingTrack ]
326
327 MFI_Clients–own
328 [ Tolerance     ;agents endorse group members desirably or undesirably
329   MeetingTrack ;list tracking all details per agent, format is below:
330         ;
331         ; 0 meeting         = number of corresponding one
332         ; 1 analysed agent = which agent is being analysed
333         ; 2 memory agent    = which agent is storing this
334         ; 3 missed meeting = boolean
335         ; 4 missed payment = boolean
336         ; 5 was sick        = boolean
337         ; 6 bad investment = boolean
338         ; 7 unprofitable    = boolean
339         ; 8 consequence     = what the group or MFI did to this person: leader
340         ;     or group visit household, vote for expelling, MFI or group fine.
341         ; 9 loss            = covered agent loss, did not covered loss, no loss
342         ; 10 event    = acceptable, unacceptable or MyCondition
343         ; 11 current debt  = what is involved
344         ; 12 event order    = what happened first
345   ;
346   ; Boolean
347   ;
348   IsBadInvestor    IsSick    IsUnprofitable    MissedMeeting    Defaulted
349
350   Language             ;one from the aux–PossibleLanguages
351   Location             ;location of clients
352   Business             ;what are they doing with credit
353   PersonalDebt         ;total individual debt
354   QuotaWithInterestRate    ;set QuotaWithInterestRate per agent and meeting
355 ]
356
357 ;;;;;;;;;;;;;;;;   INITIALISE   ;;;;;;;;;;;;;;;;
358 ;
359 ; set the initial configuration of the simulation
360 ;
```

```
361 to init
362
363   clear-all                    ;resets everything to zero
364   set WriteToFile TRUE         ;set WriteToFile FALSE
365   if (WriteToFile) [ set aux-OutputFile "No log set yet." ]
366   ;output file
367   set aux-PossibleProblematicMeetings 0
368
369   ; Unacceptable
370   set aux-TotalPartialSupport 0   set aux-TotalUndesirable 0
371   set aux-TotalGroupFine      0   set aux-TotalGroupLoss    0
372   set aux-TotalMFI_Fine 0  set aux-TotalMyLoss 0  set aux-TotalVoteExpel 0
373
374   ; Acceptable
375   set aux-TotalSupport 0  set aux-TotalDesirable 0  set aux-TotalGroupVisit 0
376   set aux-TotalLeaderVisit 0  set aux-TotalCoverLoss 0  set aux-TotalNoLoss 0
377   set aux-TotalPaidOnTime  0  set aux-TotalAvoidLoss   0
378
379   ;simulation counters
380   set aux-TotalMissedMeetings 0      set aux-TotalMissedPayments 0
381   set aux-TotalSickClients    0      set aux-TotalBadInvestors   0
382   set aux-TotalUnprofitable   0
383
384   set aux-UniqueBadInvestors [ ]      set aux-UniqueSickClients  [ ]
385   set aux-Summary [ ]   set aux-PlotData [ ]  set aux-UniqueUnprofitable [ ]
386
387   set aux-DisUnpBIn 0  set aux-DisBInUnp 0  set aux-UnpDisBIn 0
388   set aux-UnpBInDis 0  set aux-BInUnpDis 0  set aux-BInDisUnp 0
389
390   random-seed 987654321
391
392   if (MaxAgentDebt <= MinAgentDebt)  ;stop if this mistake happens
393   [ user-message "MaxDebt CAN'T be higher or equal than MinAgentDebt." stop ]
394
395   ; Configure all possible LOCATIONS
396   set aux-PossibleLocations [  ["Palenque"   "17.50798988" "-91.99140072"]
```

```
397                 ["Zinacantán"                    "16.76961756" "-92.70765781"]
398                 ["Yajalon"                       "17.17552193" "-92.33510971"]
399                 ["Tila"                          "17.299772" "-92.425797"]
400                 ["Teopisca"                      "16.532464" "-92.469976"]
401                 ["Salto de Agua"                 "17.60083013" "-92.29820251"]
402                 ["Pantelhó"                      "17.16900257" "-92.29820251"]
403                 ["Larrainzar"                    "17.04431178" "-92.48840332"]
404                 ["La Libertad"                   "17.65645414" "-91.87797546"]
405                 ["Ixtapa"                        "16.96880055" "-92.67860413"]
406                 ["Escuintla"                     "15.50132583" "-92.67860413"]
407                 ["Chilon"                        "17.07188219" "-92.43209839"]
408                 ["Chenalho"                      "17.0600668" "-92.43209839"]
409                 ["La Zacualpa"                   "15.32259841" "-92.4066925"]
410                 ["Catazaja"                      "17.69112866" "-92.1697998"]
411                 ["Jitotol"                       "17.01739387" "-92.68203735"]
412                 ["Pueblo Nuevo"                  "15.38152924" "-92.68203735"]
413                 ["Chiapa de Corzo"               "16.66842646" "-92.82966614"]
414                 ["Motozintla de Mendoza"         "15.53572971" "-92.41149902"]
415                 ["Pueblo Nuevo Solistahuacan"    "17.10863641" "-92.72117615"]
416                 ["San Cristobal de las Casas"    "16.90968362" "-92.72117615"] ]
417
418   ; Configure all possible LANGUAGES apart from Spanish.
419   ; "" are omitted from vector entries below for formatting purposes.
420   set aux-PossibleLanguages ["Tsotsil" "Tseltal" "Chol" "Tojolabal" "Zoque"
421       "Mam"]
422
423
424
425   ; Set all possible RURAL business in this format [SpanishTitle EnglishTitle]
426   ;
427   set aux-PossileRuralBusiness [["Floricultura"   "Floriculture"  "Ornament" ]
428                                 ["Frijol"         "Beans"       "Agriculture" ]
429                                 ["Cafe"           "Coffe"       "Agriculture" ]
430                                 ["Maiz"           "Maize"       "Agriculture" ]
431                                 ["Animales"       "Husbandry"   "Livestock" ]
432                 ["Frutas y Legumbres" "Fruits and Vegetables" "Agriculture" ] ]
```

```
433
434   ; Set all possible URBAN business in this format: SpanishTitle Title Category
435   ;
436   set aux-PossibleUrbanBusiness [ ["Abarrotes"      "Groceries"     "Trade"]
437                                   ["Panaderia"      "Bakery"        "Trade"]
438                                   ["Refaccionaria"  "Vehicle parts" "Trade"]
439                                   ["Talabarteria"   "Leather Shop"  "Trade"]
440                                   ["Plasticos"      "Plastics"      "Trade"]
441
442                                   ;Drink
443                                   ["Aguas Frescas"  "non-alcoholic" "Drink"]
444                                   ["Pozol"          "non-alcoholic" "Drink"]
445                                   ["Cana"           "alcoholic"     "Drink"]
446                                   ["Refrescos"      "non-alcoholic" "Drink"]
447
448                                   ;Food
449                                   ["Quesos"     "Cheese"     "Food"]
450                                   ["Tortillas"  "Tortillas"  "Food"]
451                                   ["Antojitos"  "Antojitos"  "Food"]
452                                   ["Atole"      "cereal"     "Food"]
453                                   ["Helados"    "Ice cream"  "Food"]
454                                   ["Dulces"     "Candies"    "Food"]
455                                   ["Embutidos"  "Sausages"   "Food"]
456                                   ["Pan"        "Bread"      "Food"]
457                                   ["Comida"     "dishes"     "Food"]
458                                   ["Pollo"      "Chicken"    "Food"]
459                                   ["Lacteos"    "Dairy"      "Food"]
460                                   ["Tamales"    "Tamales"    "Food"]
461                                   ["Pescado"    "Fish"       "Food"]
462                                   ["Tostadas"   "Toasts"     "Food"]
463
464                                   ;Leisure
465                                   ["Pinatas"  "Pinata"    "Leisure"]
466                                   ["Hamacas"  "Hammocks"  "Leisure"]
467
468                                   ;Art
```

```
469                              ["Artesania" "Handicraft" "Art"]
470
471
472                              ;Services
473                              ["Carpinteria" "Carpentry" "Service"]
474                              ["Catalago"    "Catalogue" "Service"]
475
476                              ;Personal care
477                              ["Costurera"  "Seamstress"   "Personal care"]
478                              ["Alhajas"    "Jewellery"    "Personal care"]
479                              ["Cosmeticos" "Cosmestics"   "Personal care"]
480                              ["Calzado"    "Shoes"        "Personal care"]
481                              ["Ropa"       "Clothing"     "Personal care"]
482                              ["Estetica"   "Beauty Salon" "Personal care"]
483                            ]
484
485   setup-agents                              ;to allow configuring properties
486   configure-agents                          ;along with their problems
487   if (WriteToFile) [ setup-output-file ] ;create file output
488 end
489
490 ;;;;;;;;;;;;;;;; CONFIGURE AGENTS ;;;;;;;;;;;;;;;;;;;;;;
491 ;
492 ; set all parameters per agent
493 ;
494 to configure-agents
495  locals [aux-i aux-List aux-Debt aux-Agent aux-LowerDebt aux-Tolerance]
496
497  ;create lists for calculating different Tolerance distributions
498  set aux-Agent      0
499  set aux-Debt       0
500  set aux-LowerDebt  0 ;when EqualCredit is set, use the fieldwork findings
501  set aux-List       [ ]
502
503  while [aux-Agent < MFI-Group]
504  [ ;reset this to create individual tolerance of all agents in their group
```

```
505     set aux-i 0
506
507     ask turtle aux-Agent
508     [  ;initialise Tolerance
509        set Tolerance [ ]       set aux-Tolerance [ ]     set MeetingTrack [ ]
510        set IsSick false    set IsBadInvestor false  set IsUnprofitable false
511
512        ;configure agent language
513        set Language []
514        set Language lput (item (random (length aux-PossibleLanguages))
515          aux-PossibleLanguages) Language ; Pick-up a random language
516        ;depending on location, Rural clients know Mayan and Urban also Spanish
517        if not (Rural) [ set Language lput "Spanish" Language ]
518
519        ;configure the agent business, rural or urban
520        ifelse (Rural)
521          [set Business item (random (length aux-PossileRuralBusiness))
522             aux-PossileRuralBusiness ]
523          [set Business item (random (length aux-PossibleUrbanBusiness))
524            aux-PossibleUrbanBusiness]
525
526        ;deal with random tolerance, going through all clients apart from itself
527        while [aux-i < MFI-Group]
528        [ if (aux-i != aux-Agent) ;it isn't the same client
529          [ ask turtle aux-Agent
530              [ set aux-Tolerance lput aux-i aux-Tolerance
531                set aux-List [ ]
532                ;0 intolerant, 1 tolerant
533                set aux-List lput random 2 aux-List
534                ifelse (item 0 aux-List = 0)
535                  [ set aux-Tolerance lput "intolerant" aux-Tolerance ]
536                  [ set aux-Tolerance lput "tolerant" aux-Tolerance   ]
537                set Tolerance lput aux-Tolerance Tolerance
538                set aux-Tolerance [ ]
539              ]
540          ]
```

```
541           set aux-i aux-i + 1
542         ]
543
544         ;configure Debts
545         ifelse (EqualCredit)
546           [ ;set the LowerDebt as 33% distribution MIN according fieldwork
547             set aux-LowerDebt ( (MaxAgentDebt * 33.33) / 100)
548
549             ; make sure the debt is between the range and the same credit
550             while [ (aux-Debt < aux-LowerDebt) or (aux-Debt > MaxAgentDebt) ]
551               [ set aux-Debt precision (random-float MaxAgentDebt ) 2 ]
552           ]
553           ; make sure the debt is between the range and with different credits
554           ;random-exponential, random-gamma, random-normal, random-poisson
555           [ set aux-Debt 0
556             ;give the chance of each agent to receive a different credit
557             while [ (aux-Debt < MinAgentDebt) or (aux-Debt > MaxAgentDebt) ]
558
559               [ set aux-Debt precision (random-float MaxAgentDebt) 2 ]
560             set PersonalDebt aux-Debt
561           ]
562
563         set PersonalDebt aux-Debt ;without interest rate
564
565         ; QuotaWithInterestRate = PersonalDebtInterestRate
566         ; + PersonalDebt / Repayments
567
568         ;added interest rate
569         set QuotaWithInterestRate precision ( ( ( (PersonalDebt * InterestRate)
570           / 100) + PersonalDebt ) / Repayments ) 2
571     ]
572     set aux-Agent aux-Agent + 1
573   ]
574
575   set aux-List [ ]
576
```

```
577   set aux-List (item (random (length aux-PossibleLocations))
578     aux-PossibleLocations)  ;pickup one location
579
580   ask MFI_Clients
581     [ set Location [ ]
582       set Location aux-List
583     ]
584
585   ;all debt without interest rate
586   set aux-Debt precision (sum values-from MFI_Clients [PersonalDebt]) 2
587
588   ;show "Personal Debts without order: " +
589   ;     values-from MFI_Clients [PersonalDebt] ;debug
590
591   ; show "Total Group Debt without interest rate: " + aux-Debt ;debug
592
593   set aux-TotalGroupDebt precision ( ( (aux-Debt * InterestRate / 100)
594     * Repayments ) + aux-Debt ) 2
595
596   ;show "Total Group Debt WITH interest rate: " + aux-TotalGroupDebt ;debug
597
598   ;show "Total interest rate: " + precision ( (aux-Debt * InterestRate / 100)
599   ;    * Repayments) 2;debug
600 end
601
602 ;;;;;;;;;;;; DEFAULTING EXTERNAL INVESTMENT INFLUENCE ;;;;;;;;;;;;;;;;;;
603 ; select how exogenous defaulting influences might operate
604
605 to setup-defaulting-investment-influence
606   locals [ aux-Chosen ]
607   ;should Bad-Investors occur, initialise counters
608   if (Bad-Investors > 0)
609     [ ;and (AffectUnique) )
610       ifelse    (Bad-Investors + Unprofitable-Clients >= MFI-Group)
611             or (Bad-Investors >= MFI-Group)
612       [ user-message "Unique/Possible Bad-Investors and Unprofitable-Clients
```

```
613                                   CAN'T be higher or equal than MFI-Group." ]
614       [ if (Bad-Investors >= 1)
615         [ ;bad investors can happen at any meeting
616           set aux-PossibleProblematicMeetings Repayments
617           set aux-Chosen [ ] ;set the non-unique affected clients
618           while [ length aux-UniqueBadInvestors < Bad-Investors ]
619             [ set aux-Chosen one-of MFI_Clients
620               ;ifelse (AffectUnique)
621                 ;[
622                   while [ (member? aux-Chosen aux-UniqueBadInvestors) or
623                           (member? aux-Chosen aux-UniqueUnprofitable) ]
624                     [ set aux-Chosen one-of MFI_Clients ]
625                 ;]
626 ;                [ while [ (member? aux-Chosen aux-UniqueBadInvestors) ]
627 ;                    [ set aux-Chosen one-of MFI_Clients ]
628 ;                ]
629               set aux-UniqueBadInvestors lput aux-Chosen aux-UniqueBadInvestors
630             ]
631           set aux-UniqueBadInvestors sort aux-UniqueBadInvestors
632           foreach aux-UniqueBadInvestors [ ask ? [set IsBadInvestor true ] ]
633         ]
634
635         ;show "aux-UniqueBadInvestors: " + aux-UniqueBadInvestors
636         if (aux-PossibleProblematicMeetings > Repayments)
637           [ set aux-PossibleProblematicMeetings Repayments ] ;in case
638       ]
639     ]
640 end
641
642 ;;;;;;;;;;;; DEFAULTING EXTERNAL UNPROFITABLE INFLUENCES ;;;;;;;;;;;;;;;;;
643 ; select how exogenous defaulting influences might operate
644
645 to setup-defaulting-unprofitable-influence
646   locals [ aux-Chosen ]
647
648   ;should Unprofitable-Clients occur, initialise counters
```

```
649   if (Unprofitable-Clients > 0)
650     [  ;and (AffectUnique) )
651       ifelse (Unprofitable-Clients + Bad-Investors >= MFI-Group)
652           or (Unprofitable-Clients >= MFI-Group)
653       [ user-message "Possible Unprofitable Clients and Bad-Investors
654                                   CAN'T be higher or equal than MFI-Group." ]
655
656       [  if (Unprofitable-Clients >= 1 )
657         [ set aux-Chosen [ ]
658           ;ensure there is a unique, random list of Unprofitable-Clients
659           while [ length aux-UniqueUnprofitable < Unprofitable-Clients ]
660           [ set aux-Chosen one-of MFI_Clients
661 ;             ifelse (AffectUnique)
662 ;               [
663                   while [ (member? aux-Chosen aux-UniqueUnprofitable) or
664                           (member? aux-Chosen aux-UniqueBadInvestors) ]
665                     [ set aux-Chosen one-of MFI_Clients ]
666 ;               ]
667 ;               [ while [ (member? aux-Chosen aux-UniqueUnprofitable) ]
668 ;                   [ set aux-Chosen one-of MFI_Clients ]
669 ;               ]
670             set aux-UniqueUnprofitable lput aux-Chosen aux-UniqueUnprofitable
671           ]
672           set aux-UniqueUnprofitable sort aux-UniqueUnprofitable
673           foreach aux-UniqueUnprofitable [ ask ? [set IsUnprofitable true ] ]
674         ]
675
676         ;show "aux-UniqueUnprofitable: " + aux-UniqueUnprofitable
677         if (aux-PossibleProblematicMeetings > Repayments)
678           [ set aux-PossibleProblematicMeetings Repayments ];in case
679       ]
680     ]
681 end
682
683 ;;;;;;;;;;; DEFAULTING EXTERNAL DISEASE INFLUENCE ;;;;;;;;;;;;;;;;;;
684 ; select how exogenous defaulting influences might operate
```

```
685 to setup-defaulting-disease-influence
686   locals [ aux-Chosen ]
687
688   ;should diseases occur, initialise counters
689   if (Disease-Incidence > 0 )
690     [ ;create a number of possible diseases occurrences based on the
691       ;Disease-Incidence percentage with regards to number of Repayments
692       set aux-PossibleDiseaseEvents round
693         ((Disease-Incidence * Repayments) / 100 )
694
695       ;count only once aux-PossibleProblematicMeetings
696       if not any? MFI_Clients with [IsSick = true]
697         [ set aux-PossibleProblematicMeetings aux-PossibleProblematicMeetings
698                 + aux-PossibleDiseaseEvents ]
699
700 ;
701 ;       ifelse (DiseaseAffects = "Single Client")
702 ;         [  ;kept the same sick agent during a credit cycle
703               if (length aux-UniqueSickClients = 0)
704
705             [ set aux-UniqueSickClients lput one-of
706                     MFI_Clients aux-UniqueSickClients
707               foreach aux-UniqueSickClients [ ask ? [ set IsSick true ] ]
708             ]
709
710 ;         ]
711 ;         [ set aux-Chosen [ ] ;to set the non-unique, multiple affected clients
712 ;           show round (Disease-Incidence * MFI-Group / 100)
713 ;                       + " NUMBER OF SICK AGENTS  ";debug
714 ;
715 ;           while [ length aux-UniqueSickClients < round  (Disease-Incidence
716 ;                       * MFI-Group / 100) ]; (random (count MFI_Clients) ) ]
717 ;             [ set aux-Chosen one-of MFI_Clients
718 ;               while [ member? aux-Chosen aux-UniqueSickClients ]
719 ;                 [ set aux-Chosen one-of MFI_Clients ]
720 ;               set aux-UniqueSickClients lput aux-Chosen aux-UniqueSickClients
```

```
721 ;             ]
722 ;           set aux-UniqueSickClients sort aux-UniqueSickClients
723 ;           foreach aux-UniqueSickClients [ ask ? [set IsSick true ] ]
724 ;         ]
725 ;       show "aux-UniqueSickClients: " + aux-UniqueSickClients;debug
726 ;       regardless how disease works, add its incidence to troubled meetings
727
728       if (aux-PossibleProblematicMeetings > Repayments)
729         [ set aux-PossibleProblematicMeetings Repayments ];in case
730     ]
731 end
732
733 ;;;;;;;;;;;;;;;;  SETUP AGENTS  ;;;;;;;;;;;;;;;;
734 ;
735 ; add agents to the simulation, clients and advisor
736 ;
737
738 to setup-agents
739  create-custom-MFI_Clients MFI-Group [ ]
740  create-custom-MFI_Adviser 1 [ set MeetingTrack [ ] ]
741
742  ;have an ordered list of all agents throughout the simulation
743  set aux-OrderedGroup [ ] ;to avoid zombies (agents called "nobody")
744  set aux-OrderedGroup sort MFI_Clients
745 end
746
747 ;;;;;;;;;;;;;;;;  WRITE THE OUTPUT FILE  ;;;;;;;;;;;;;;;;
748 ; format the results
749 to setup-output-file
750   locals [aux-i aux-j]
751
752   set aux-OutputFile (remove ":" date-and-time) + ", " + Runs + " runs, "
753         + MFI-Group + " members, " + Repayments + " repayments.csv"
754
755   file-open aux-OutputFile
756   file-print date-and-time
```

```
757
758   file-type "Solidarity Group with: " + MFI-Group
759   ifelse (Rural)
760     [file-print " RURAL family members." ]
761     [file-print " URBAN neighbour members." ]
762
763   file-print "Disease Incidence: "    + Disease-Incidence
764   ;+ " . Disease Affects: "  +  DiseaseAffects
765
766   file-print "Unprofitable Clients: " + Unprofitable-Clients +
767                " . Bad Investors: " + Bad-Investors
768
769   file-print "MINimum debt: "  + MinAgentDebt +
770                " . MAXimum debt: "  +  MaxAgentDebt
771
772   ifelse (EqualCredit)
773     [ file-type "EQUAL " ]
774     [ file-type "UNEQUAL " ]
775   file-print "Credit distribution."
776
777   file-print "Repayments: "  + Repayments + " . Runs: "        + Runs
778   file-print "Maximum Potentially Problematic Meetings (MPPM)."
779   file-print " "
780 end
781
782 ;;;;;;;;;;;;;;;;  SIMULATE  ;;;;;;;;;;;;;;;;
783 ;
784 ; run the model
785 ;
786 to go
787   locals [ aux-i aux-L1 aux-L2 aux-L3 aux-L4 aux-L5
788              aux-L6 aux-desirableNumber aux-EqualNumber
789              aux-undesirableNumber aux-CurrentIteration ]
790
791   reset-timer ;global tick count is 0
792   set aux-Run 1
```

```
793   set aux-LoggedEventOrder 1.1
794   set aux-L1 [ ]   set aux-L2 [ ]  set aux-L3 [ ]
795   set aux-L4 [ ]   set aux-L5 [ ]  set aux-L6 [ ]
796
797   set aux-Repayment          0   set aux-desirableNumber   0
798   set aux-EqualNumber        0   set aux-undesirableNumber 0
799
800   ;stop if this happens
801   if (aux-OutputFile = "nothing set yet")
802     [ user-message "No OUTPUT has been defined." stop ]
803
804   ;write evolution of events per simulation
805   if (WriteToFile) [ file-print "ProblemOrder, TotalLeaderVisit, TotalGroupVisit
806
807   set aux-ProblemsOrderList [ ]
808
809   ;write results per simulation cycle
810   while [aux-Run <= Runs ]
811   [ ;write results per meeting
812     while [aux-Repayment <= Repayments]
813     [ ;if (WriteToFile) [ file-type "#Meeting " + aux-Repayment
814       ;if (aux-Repayment = 0) [ file-print ", START" ] ]
815       meeting;go through what a meeting is supposed to be
816
817       ; order of aux-ProblemsOrderList [ [aux-DisUnpBIn, aux-DisBInUnp,
818       ; aux-UnpDisBIn, aux-UnpBInDis, aux-BInUnpDis, aux-BInDisUnp] ]
819
820       set aux-L6 lput aux-DisUnpBIn aux-L6
821       set aux-L6 lput aux-DisBInUnp aux-L6
822       set aux-L6 lput aux-UnpDisBIn aux-L6
823       set aux-L6 lput aux-UnpBInDis aux-L6
824       set aux-L6 lput aux-BInUnpDis aux-L6
825       set aux-L6 lput aux-BInDisUnp aux-L6
826       set aux-ProblemsOrderList lput aux-L6 aux-ProblemsOrderList
827       set aux-L6 [ ]
828       set aux-Repayment aux-Repayment + 1
```

```
829       ]
830
831       ;reset counters of all meetings problems
832       set aux-BInDisUnp 0     set aux-BInUnpDis 0
833       set aux-UnpBInDis 0     set aux-UnpDisBIn 0
834       set aux-DisBInUnp 0     set aux-DisUnpBIn 0
835
836       if (WriteToFile) [
837       file-print " " file-print " "
838       file-print "#Run " + aux-Run    ]
839
840       ;ElapsedTime, Cycle, LoggedEvents, ...
841       set aux-Summary lput timer aux-Summary
842
843       ;move along to the second meeting with correct values
844       if (Plots) [
845         set-current-plot      "Elapsed Time"
846         set-current-plot-pen "timer"
847         plotxy aux-Run timer ;item aux-Summary ;timer for the current simulation
848       ]
849
850       reset-timer
851       set aux-LoggedEventOrder 1.1
852
853       ;log the complete history of all agents in order of events
854       ;put all events in one auxilar list
855       foreach aux-OrderedGroup [ ask ?
856                                    [ without-interruption
857                                       [ foreach MeetingTrack
858                                        ;to avoid the [] bug caught in aux-Memory
859                                         [ if (length ? != 0) [
860                                           foreach ? [ set aux-L1 lput ? aux-L1 ]
861                                           set aux-L2 lput aux-L1 aux-L2
862                                           set aux-L1 [ ]
863                                           ]
864                                        ]
```

```
865                                        ]
866                                      ]
867                                    ]
868
869     ;sort them all by eventID
870     set aux-L2 (sort-by [item 12 ?1 < item 12 ?2 ] aux-L2)
871
872     ;write all their languages and businesses
873     set aux-i 0
874     if (WriteToFile) [
875       file-print "Language, , , , Business, , , ,Location"
876       while [aux-i < MFI-Group]
877         [ ;file-type "Client: " + (aux-i ) + ", "
878           foreach value-from item aux-i aux-OrderedGroup [Language]
879             [ file-type ? + ", " ]
880           file-type ", "
881
882           if (Rural) [ file-type ", " ]
883           foreach value-from item aux-i aux-OrderedGroup [Business]
884             [ file-type ? + ", " ]
885           file-type ", "
886
887           foreach value-from item aux-i aux-OrderedGroup [Location]
888             [ file-type ? + ", " ]
889           file-print " "
890
891           set aux-i aux-i + 1
892         ]
893
894       file-print " "
895
896       ;log all their history during the credit cycle
897       file-print "Meeting, Analysed, Memory, MissedMeeting, MissedPayment,
898                   IsSick, IsBadInvestor, IsUnprofitable, Consequence, Payment,
899                   Status, DebtFocus, EventOrder, #EventCount";, TotalDebt" ]
900     set aux-i 1
```

```
901     ;write them all
902     foreach aux-L2
903       [ foreach ?
904         [ if (WriteToFile) [
905             ifelse (is-agent? ?)
906               [ file-type "client_" + who-of ? + " , "]
907               [ file-type ? + " , " ]
908           ] ]
909         if (last aux-L2 = ?)
910           [  ;ElapsedTime, Cycle, LoggedEvents,
911             set aux-Summary lput ("Cycle:" + aux-Run) aux-Summary
912             set aux-Summary lput aux-i aux-Summary ]
913
914         if (WriteToFile)
915           [  file-type aux-i
916             file-print " " ]
917
918         set aux-i aux-i + 1 ]
919
920     if (WriteToFile) [
921     file-print " "
922     file-print "ProblemOrder, TotalLeaderVisit, TotalGroupVisit,
923             TotalGroupVisit, TotalSupport, TotalVoteExpel, TotalFines" ]
924
925     ;criteria for evaluating groups
926     ifelse (aux-TotalDesirable > aux-TotalUndesirable)
927      [ set aux-Summary lput "acceptable" aux-Summary
928        set aux-desirableNumber aux-desirableNumber + 1
929        set aux-CurrentIteration "acceptable"
930      ]
931
932      [ ifelse (aux-TotalDesirable = aux-TotalUndesirable)
933          [ set aux-Summary lput "Equal P&N" aux-Summary
934            set aux-EqualNumber aux-EqualNumber + 1
935            set aux-CurrentIteration "equal"
936          ]
```

```
937           [ set aux-Summary lput "unacceptable" aux-Summary
938             set aux-undesirableNumber aux-undesirableNumber + 1
939             set aux-CurrentIteration "unacceptable"
940           ] ]
941
942       ; ElapsedTime, Cycle, #Events, Final Status, #Acceptable, #Unacceptable,
943       ; #LEADER_Visit, #GROUP_Visit, #COVER_Loss, #NO_Loss, #PaidOnTime,
944       ; #AVOID_Loss, #Full_Support, Missed Meetings, Missed Payments,
945       ; #ExpelVote,#MFIFine, #GroupFine, GroupLoss, #MyLoss, #PartialSupport,
946       ; EventsWithSickClients, EventsWithBadInvestors, EventsWithUnprofitable
947
948       set aux-Summary lput aux-TotalDesirable      aux-Summary
949       set aux-Summary lput aux-TotalUndesirable    aux-Summary
950
951       set aux-Summary lput aux-TotalLeaderVisit aux-Summary
952       set aux-Summary lput aux-TotalGroupVisit  aux-Summary
953       set aux-Summary lput aux-TotalCoverLoss   aux-Summary
954       set aux-Summary lput aux-TotalNoLoss      aux-Summary
955
956       set aux-Summary lput aux-TotalPaidOnTime  aux-Summary
957       set aux-Summary lput aux-TotalAvoidLoss   aux-Summary
958       set aux-Summary lput aux-TotalSupport     aux-Summary
959
960       set aux-Summary lput aux-TotalMissedMeetings aux-Summary
961       set aux-Summary lput aux-TotalMissedPayments aux-Summary
962       set aux-Summary lput aux-TotalVoteExpel      aux-Summary
963       set aux-Summary lput aux-TotalMFI_Fine       aux-Summary
964       set aux-Summary lput aux-TotalGroupFine      aux-Summary
965       set aux-Summary lput aux-TotalGroupLoss      aux-Summary
966       set aux-Summary lput aux-TotalMyLoss         aux-Summary
967       set aux-Summary lput aux-TotalPartialSupport aux-Summary
968
969       set aux-Summary lput aux-TotalSickClients    aux-Summary
970       set aux-Summary lput aux-TotalBadInvestors   aux-Summary
971       set aux-Summary lput aux-TotalUnprofitable   aux-Summary
972
```

```
973     ;visual graphs of all that happens, plus log data
974     ;do the plots if there is something useful to be shown
975     ;
976     if ( ( (aux-TotalDesirable != 0) or (aux-TotalUndesirable != 0)
977             or (aux-EqualNumber != 0) ) and (Plots) ) [
978       set-current-plot      "Total group outcomes"
979       set-current-plot-pen "Acceptable"
980       plot aux-desirableNumber
981
982       set-current-plot-pen "Equal"
983       plot aux-EqualNumber
984
985       set-current-plot-pen "Unacceptable"
986       plot aux-undesirableNumber
987
988       set-current-plot "Individual debts"
989       set-current-plot-pen "PersonalDebt"
990       foreach values-from MFI_Clients [ PersonalDebt ] [ plot ? ]
991       set-current-plot-pen "QuotaWithInterestRate"
992       foreach values-from MFI_Clients [ QuotaWithInterestRate ] [ plot ? ]
993      ]
994
995     ;
996     ; no visual plots, but still log the data
997     ;
998     ifelse (aux-CurrentIteration = "acceptable")
999       [ set aux-PlotData lput "Acceptable"   aux-PlotData ]
1000      [ ifelse (aux-CurrentIteration = "unacceptable")
1001        [ set aux-PlotData lput "UNdesirable" aux-PlotData ]
1002        [ set aux-PlotData lput "Equal" aux-PlotData ] ]
1003
1004    ifelse (aux-TotalLeaderVisit != 0)
1005     [ set aux-PlotData lput aux-TotalLeaderVisit aux-PlotData ]
1006     [ set aux-PlotData lput 0 aux-PlotData                    ]
1007
1008    ifelse (aux-TotalGroupVisit != 0)
```

```
1009      [ set aux-PlotData lput aux-TotalGroupVisit aux-PlotData    ]
1010      [ set aux-PlotData lput 0 aux-PlotData                      ]
1011
1012      ifelse (aux-TotalCoverLoss != 0)
1013      [ set aux-PlotData lput aux-TotalCoverLoss aux-PlotData     ]
1014      [ set aux-PlotData lput 0 aux-PlotData                      ]
1015
1016      ifelse (aux-TotalVoteExpel != 0)
1017      [ set aux-PlotData lput aux-TotalVoteExpel aux-PlotData     ]
1018      [ set aux-PlotData lput 0 aux-PlotData                      ]
1019
1020      ifelse (aux-TotalSupport != 0) or (aux-TotalPartialSupport != 0)
1021      [ set aux-PlotData lput (aux-TotalSupport + aux-TotalPartialSupport)
1022            aux-PlotData ]
1023      [ set aux-PlotData lput 0 aux-PlotData ]
1024
1025      ifelse (aux-TotalMFI_Fine != 0) or (aux-TotalGroupFine != 0)
1026      [ set aux-PlotData lput (aux-TotalMFI_Fine + aux-TotalGroupFine)
1027              aux-PlotData     ]
1028      [ set aux-PlotData lput 0 aux-PlotData ]
1029
1030      ;unacceptable
1031      set aux-TotalPartialSupport 0   set aux-TotalVoteExpel    0
1032      set aux-TotalMFI_Fine       0     set aux-TotalMyLoss     0
1033      set aux-TotalGroupFine      0     set aux-TotalGroupLoss  0
1034      set aux-TotalUndesirable    0
1035
1036      ;acceptable
1037      set aux-TotalSupport      0     set aux-TotalDesirable    0
1038      set aux-TotalLeaderVisit  0     set aux-TotalGroupVisit   0
1039      set aux-TotalCoverLoss    0     set aux-TotalNoLoss       0
1040      set aux-TotalPaidOnTime   0     set aux-TotalAvoidLoss    0
1041
1042      ;simulation counters
1043      set aux-TotalMissedMeetings 0     set aux-TotalMissedPayments 0
1044      set aux-TotalSickClients    0     set aux-TotalBadInvestors   0
```

```
1045      set aux-TotalUnprofitable    0
1046
1047      ;reconfigure agents for a new run
1048      clear-turtles
1049
1050      ;to not repeat one more than needed
1051      if (aux-Run < Runs)
1052       [ ;only setup them again if needed
1053         setup-agents
1054         configure-agents
1055         set aux-PossibleProblematicMeetings 0
1056         set aux-Repayment                   0
1057
1058         set aux-UniqueBadInvestors [ ]
1059         set aux-UniqueSickClients  [ ]
1060         set aux-UniqueUnprofitable [ ]
1061
1062         ;to avoid zombies
1063         set aux-L1 [ ]
1064         set aux-L2 [ ]
1065       ]
1066      set aux-Run aux-Run + 1
1067    ]
1068
1069    set aux-i 0
1070    set aux-L1 []
1071    set aux-L2 []
1072
1073    ;put all events in one auxilar list
1074    ;get all items to output, according to the log's length
1075    foreach aux-Summary [ ifelse (aux-i <= 23)
1076                            [ set aux-L1 lput ? aux-L1
1077                              set aux-i aux-i + 1 ]
1078                            [ set aux-L2 lput aux-L1 aux-L2
1079                              set aux-L1 []
1080                              set aux-L1 lput ? aux-L1
```

```
1081                                set aux-i 1 ] ]
1082
1083    set aux-L2 lput aux-L1 aux-L2 ;to catch the last simulation summary
1084
1085    ;very detailed log, with all events
1086    if (WriteToFile) [
1087      file-print " "
1088      file-type "ElapsedTime, Cycle, #Events, Final Status, #Acceptable,
1089              #Unacceptable, #LEADER_Visit, "
1090      file-type "#GROUP_Visit, #COVER_Loss, #NO_Loss, #PaidOnTime,
1091              #AVOID_Loss, #Full_Support, "
1092      file-type "Missed Meetings, Missed Payments, #ExpelVote, #MFIFine,
1093              #GroupFine, #GroupLoss,"
1094      file-print "#MyLoss, #PartialSupport, EventsWithSickClients,
1095              EventsWithBadInvestors, EventsWithUnprofitable"
1096
1097      foreach aux-L2
1098        [ foreach ? [ file-type ? + " , " ]
1099          file-print " " ]
1100
1101      file-print "#acceptable: "      + aux-desirableNumber
1102      file-print "#Equal P&N log: " + aux-EqualNumber
1103      file-print "#unacceptable: "    + aux-undesirableNumber
1104    ]
1105
1106    ;
1107    ; log only containing plot data
1108    ;
1109    set aux-i 0
1110    set aux-L1 [ ]
1111    set aux-L2 [ ]
1112    foreach aux-PlotData [
1113      ifelse (aux-i <= 6) [
1114        set aux-L1 lput ? aux-L1
1115        set aux-i aux-i + 1    ]
1116      [ set aux-L2 lput aux-L1 aux-L2
```

```
1117        set aux-L1 []
1118        set aux-L1 lput ? aux-L1
1119        set aux-i 1 ] ]
1120
1121    set aux-L2 lput aux-L1 aux-L2
1122
1123    ;to help separating each result
1124    set aux-L2 (sort-by [item 0 ?1 < item 0 ?2 ] aux-L2)
1125
1126  ;  aux-L1 = Equal, aux-L3 = Acceptable, aux-L4 = Unacceptable
1127    set aux-L1 []
1128
1129    foreach aux-L2
1130    [ set aux-L5 lput item 0 ? aux-L5
1131      set aux-L5 lput item 1 ? aux-L5
1132      set aux-L5 lput item 2 ? aux-L5
1133      set aux-L5 lput item 3 ? aux-L5
1134      set aux-L5 lput item 4 ? aux-L5
1135      set aux-L5 lput item 5 ? aux-L5
1136      set aux-L5 lput item 6 ? aux-L5
1137
1138      ifelse (item 0 ? = "Equal")
1139      [ set aux-L1 lput aux-L5 aux-L1 ]
1140      [ ifelse (item 0 ? = "Acceptable")
1141        [ set aux-L3 lput aux-L5 aux-L3 ]
1142        [ set aux-L4 lput aux-L5 aux-L4 ] ]
1143
1144      set aux-L5 []
1145    ]
1146
1147    ;aux-L3 = Acceptable
1148    set aux-L3 (sort-by [item 1 ?1 < item 1 ?2 ] aux-L3)
1149    set aux-L3 (sort-by [item 2 ?1 < item 2 ?2 ] aux-L3)
1150    set aux-L3 (sort-by [item 3 ?1 < item 3 ?2 ] aux-L3)
1151    set aux-L3 (sort-by [item 4 ?1 < item 4 ?2 ] aux-L3)
1152    set aux-L3 (sort-by [item 5 ?1 < item 5 ?2 ] aux-L3)
```

```
1153    set aux-L3 (sort-by [item 6 ?1 < item 6 ?2 ] aux-L3)
1154
1155    if (WriteToFile) [ file-print " "
1156      file-print "Status, #LeaderVisit, #GroupVisit, #CoveredLosses,
1157         #ExpellingVotes, #TotalSupport, #TotalFines" ]
1158    set-current-plot "Acceptable group events"
1159    foreach aux-L3 ;aux-L3 = Acceptable
1160      [ if (WriteToFile) [ foreach ? [ file-type ? + ", " ]
1161        file-print " " ]
1162
1163        set-current-plot-pen "LeaderVisit"
1164        plot item 1 ?
1165
1166        set-current-plot-pen "GroupVisit"
1167        plot item 2 ?
1168
1169        set-current-plot-pen "CoveredLosses"
1170        plot item 3 ?
1171
1172        set-current-plot-pen "ExpellingVotes"
1173        plot item 4 ?
1174
1175        set-current-plot-pen "TotalSupport"
1176        plot item 5 ?
1177
1178        set-current-plot-pen "TotalFines"
1179        plot item 6 ?
1180      ]
1181
1182    ;aux-L1 = Equal
1183    set aux-L1 (sort-by [item 1 ?1 < item 1 ?2 ] aux-L1)
1184    set aux-L1 (sort-by [item 2 ?1 < item 2 ?2 ] aux-L1)
1185    set aux-L1 (sort-by [item 3 ?1 < item 3 ?2 ] aux-L1)
1186    set aux-L1 (sort-by [item 4 ?1 < item 4 ?2 ] aux-L1)
1187    set aux-L1 (sort-by [item 5 ?1 < item 5 ?2 ] aux-L1)
1188    set aux-L1 (sort-by [item 6 ?1 < item 6 ?2 ] aux-L1)
```

```
1189
1190    if (WriteToFile) [ file-print " "
1191    file-print "Status, #LeaderVisit, #GroupVisit, #CoveredLosses,
1192        #ExpellingVotes, #TotalSupport, #TotalFines" ]
1193
1194    set-current-plot "Equal group events"
1195    foreach aux-L1 ;aux-L1 = Equal
1196      [ if (WriteToFile) [ foreach ? [ file-type ? + ", " ]
1197        file-print " " ]
1198        set-current-plot-pen "LeaderVisit"
1199        plot item 1 ?
1200
1201        set-current-plot-pen "GroupVisit"
1202        plot item 2 ?
1203
1204        set-current-plot-pen "CoveredLosses"
1205        plot item 3 ?
1206
1207        set-current-plot-pen "ExpellingVotes"
1208        plot item 4 ?
1209
1210        set-current-plot-pen "TotalSupport"
1211        plot item 5 ?
1212
1213        set-current-plot-pen "TotalFines"
1214        plot item 6 ?
1215     ]
1216
1217    ;aux-L4 = Unacceptable
1218    set aux-L4 (sort-by [item 1 ?1 < item 1 ?2 ] aux-L4)
1219    set aux-L4 (sort-by [item 2 ?1 < item 2 ?2 ] aux-L4)
1220    set aux-L4 (sort-by [item 3 ?1 < item 3 ?2 ] aux-L4)
1221    set aux-L4 (sort-by [item 4 ?1 < item 4 ?2 ] aux-L4)
1222    set aux-L4 (sort-by [item 5 ?1 < item 5 ?2 ] aux-L4)
1223    set aux-L4 (sort-by [item 6 ?1 < item 6 ?2 ] aux-L4)
1224
```

```
1225    if (WriteToFile) [ file-print " "
1226    file-print "Status, #LeaderVisit, #GroupVisit, #CoveredLosses,
1227        #ExpellingVotes, #TotalSupport, #TotalFines" ]
1228
1229    set-current-plot "Unacceptable group events"
1230    foreach aux-L4 ;aux-L4 = Unacceptable
1231      [ if (WriteToFile) [ foreach ? [ file-type ? + ", " ]
1232        file-print " " ]
1233        set-current-plot-pen "LeaderVisit"
1234        plot item 1 ?
1235
1236        set-current-plot-pen "GroupVisit"
1237        plot item 2 ?
1238
1239        set-current-plot-pen "CoveredLosses"
1240        plot item 3 ?
1241
1242        set-current-plot-pen "ExpellingVotes"
1243        plot item 4 ?
1244
1245        set-current-plot-pen "TotalSupport"
1246        plot item 5 ?
1247
1248        set-current-plot-pen "TotalFines"
1249        plot item 6 ?
1250      ]
1251
1252    if (WriteToFile) [
1253      file-close
1254      set aux-OutputFile "nothing set yet" ]
1255
1256        ;plot what happened with the order of problems
1257      if (Plots) [
1258       set-current-plot "ProblemsOrder"
1259       set-current-plot-pen "DisUnpBIn"
1260       ;plot aux-DisUnpBIn
```

```
1261        histogram-list item 0 aux-ProblemsOrderList
1262
1263        set-current-plot "ProblemsOrder"
1264        set-current-plot-pen "DisBInUnp"
1265        ;plot aux-DisBInUnp
1266        histogram-list item 1 aux-ProblemsOrderList
1267
1268        set-current-plot "ProblemsOrder"
1269        set-current-plot-pen "UnpDisBIn"
1270        ;plot aux-UnpDisBIn
1271        histogram-list item 2 aux-ProblemsOrderList
1272
1273        set-current-plot "ProblemsOrder"
1274        set-current-plot-pen "UnpBInDis"
1275        ;plot aux-UnpBInDis
1276        histogram-list item 3 aux-ProblemsOrderList
1277
1278        set-current-plot "ProblemsOrder"
1279        set-current-plot-pen "BInUnpDis"
1280        ;plot aux-BInUnpDis
1281        histogram-list item 4 aux-ProblemsOrderList
1282
1283        set-current-plot "ProblemsOrder"
1284        set-current-plot-pen "BInDisUnp"
1285        ;plot aux-BInDisUnp
1286        histogram-list item 5 aux-ProblemsOrderList
1287       ]
1288
1289     ;show aux-ProblemsOrderList
1290    ;ask MFI_Adviser [ show MeetingTrack ] ;debug
1291    stop ;stop the simulate procedure
1292 end
1293
1294 ;;;;;;;;;;;;;;;;  DISEASES  ;;;;;;;;;;;;;;;;
1295 ; define who is sick
1296 to diseases
```

```
1297  locals [ aux-SickAgents aux-Chosen aux-Memory]
1298
1299  set aux-SickAgents 0
1300  set aux-Memory [ ]
1301
1302  ifelse (aux-PossibleDiseaseEvents < 1)
1303    [ stop ] ;if there are no more disease events
1304    [ ;a person misses a meeting when: is hit by disease (19%)
1305      foreach aux-UniqueSickClients
1306      [ ifelse (random-float 100 > 50)
1307        [ ask ? [ set MissedMeeting true ]
1308          ifelse (random-float 100 < 50) ;25% of those will also miss payments
1309            [ ask ? [ set Defaulted true  ] ]
1310            [ ask ? [ set Defaulted false ] ]
1311        ]
1312        [ ask ? [ set MissedMeeting false ]
1313          ask ? [ set Defaulted     false ]
1314        ]
1315
1316        ;THIS ORDER IS VERY IMPORTANT to keep MeetingTrack correct
1317        set aux-Memory lput aux-Repayment       aux-Memory  ;meeting
1318        set aux-Memory lput ?                   aux-Memory  ;who is analysed
1319        set aux-Memory lput ?                   aux-Memory  ;who stores
1320        set aux-Memory lput MissedMeeting-of  ? aux-Memory  ;missed meeting?
1321        set aux-Memory lput Defaulted-of      ? aux-Memory  ;missed payment?
1322        set aux-Memory lput IsSick-of         ? aux-Memory  ;is sick?
1323        set aux-Memory lput IsBadInvestor-of  ? aux-Memory  ;bad investor?
1324        set aux-Memory lput IsUnprofitable-of ? aux-Memory  ;is unprofitable?
1325        set aux-Memory lput "MyStatus"          aux-Memory  ;no consequence
1326
1327        ifelse (Defaulted-of ?)
1328          [ set aux-Memory lput "MY_Loss"     aux-Memory ]   ;acknowledge loss
1329          [ set aux-Memory lput "PaidOnTime" aux-Memory ]    ;ack. payment
1330
1331        set aux-Memory lput "MyStatus"                  aux-Memory ;no event
1332        set aux-Memory lput QuotaWithInterestRate-of ? aux-Memory ;current debt
```

```
1333          set aux-Memory lput aux-LoggedEventOrder        aux-Memory ;logged order
1334
1335          ask ? [ set MeetingTrack lput aux-Memory MeetingTrack ]
1336          ;ask ? [ show "DISEASE MeetingTrack: " + MeetingTrack ];debug
1337
1338          set aux-Memory []
1339          set aux-LoggedEventOrder precision (aux-LoggedEventOrder + 0.1) 2
1340        ]
1341
1342        ;reduce the number of remaining incidents
1343        set aux-PossibleDiseaseEvents aux-PossibleDiseaseEvents - 1
1344      ]
1345  end
1346
1347  ;;;;;;;;;;;;;;;;  UNPROFITABLE  ;;;;;;;;;;;;;;;;
1348  ; define who can be unprofitable
1349  to unprofitable
1350    locals [ aux-Memory]
1351    set aux-Memory []
1352
1353    if (Unprofitable-Clients > 0)
1354    [ ;a person misses a meeting when: is unprofitable (11%)
1355      foreach aux-UniqueUnprofitable [
1356        ifelse (random-float 100 < 50 )
1357        [ ask ? [ set MissedMeeting true ]
1358          ifelse (random-float 100 > 50)  ;25% of those will also miss payments
1359            [ ask ? [ set Defaulted true  ] ]
1360            [ ask ? [ set Defaulted false ] ]
1361        ]
1362        [ ask ? [ set MissedMeeting false ]
1363          ask ? [ set Defaulted     false ]
1364        ]
1365
1366        ;ask ? [ show "MissedMeeting : " + MissedMeeting + ",
1367        ;         Defaulted: " + Defaulted ];debug
1368
```

```
1369        ;THIS ORDER IS VERY IMPORTANT to keep MeetingTrack correct
1370        set aux-Memory lput aux-Repayment        aux-Memory  ;meeting
1371        set aux-Memory lput ?                    aux-Memory  ;who analysed
1372        set aux-Memory lput ?                    aux-Memory  ;who stores
1373        set aux-Memory lput MissedMeeting-of  ?  aux-Memory  ;missed meeting?
1374        set aux-Memory lput Defaulted-of      ?  aux-Memory  ;missed payment?
1375        set aux-Memory lput IsSick-of         ?  aux-Memory  ;is sick?
1376        set aux-Memory lput IsBadInvestor-of  ?  aux-Memory  ;bad investor?
1377        set aux-Memory lput IsUnprofitable-of ?  aux-Memory  ;is unprofitable?
1378        set aux-Memory lput "MyStatus"           aux-Memory  ;no consequence
1379
1380        ifelse (Defaulted-of ?)
1381          [ set aux-Memory lput "MY_Loss"     aux-Memory ] ;acknowledge loss
1382          [ set aux-Memory lput "PaidOnTime" aux-Memory ] ;acknowledge payment
1383
1384        set aux-Memory lput "MyStatus"                    aux-Memory ;no event
1385        set aux-Memory lput QuotaWithInterestRate-of ?  aux-Memory ;current debt
1386        set aux-Memory lput aux-LoggedEventOrder          aux-Memory ;logged order
1387
1388        ask ? [ set MeetingTrack lput aux-Memory MeetingTrack ]
1389        ;ask ? [ show "Unprofitable MeetingTrack: " + MeetingTrack ];debug
1390
1391        set aux-Memory []
1392        set aux-LoggedEventOrder precision (aux-LoggedEventOrder + 0.1) 2
1393      ]
1394    ]
1395  end
1396
1397
1398  ;;;;;;;;;;;;;;;;  BAD INVESTOR  ;;;;;;;;;;;;;;;;
1399  ; define the bad investors prior to credit administration
1400  ;
1401  to badinvestor
1402    locals [ aux-Memory]
1403    set aux-Memory []
1404
```

```
1405    if (Bad-Investors > 0)
1406    [ ;a person misses a meeting when:     is a bad investor (9%)
1407      foreach aux-UniqueBadInvestors [
1408        ifelse (random-float 100 > 50 )
1409        [ ask ? [ set MissedMeeting true ]
1410          ifelse (random-float 100 < 50)  ;25% of those will also miss payments
1411            [ ask ? [ set Defaulted true  ] ]
1412            [ ask ? [ set Defaulted false ] ] ]
1413        [ ask ? [ set MissedMeeting false ]
1414          ask ? [ set Defaulted     false ] ]
1415
1416        ;ask ? [ show "MissedMeeting : " + MissedMeeting + ",
1417        ;         Defaulted: " + Defaulted ];debug
1418
1419        ;THIS ORDER IS VERY IMPORTANT to keep MeetingTrack correct
1420        set aux-Memory lput aux-Repayment        aux-Memory  ;meeting
1421        set aux-Memory lput ?                    aux-Memory  ;who is analysed
1422        set aux-Memory lput ?                    aux-Memory  ;who stores
1423        set aux-Memory lput MissedMeeting-of  ? aux-Memory  ;missed meeting?
1424        set aux-Memory lput Defaulted-of      ? aux-Memory  ;missed payment?
1425        set aux-Memory lput IsSick-of         ? aux-Memory  ;is sick?
1426        set aux-Memory lput IsBadInvestor-of  ? aux-Memory  ;bad investor?
1427        set aux-Memory lput IsUnprofitable-of ? aux-Memory  ;is unprofitable?
1428        set aux-Memory lput "MyStatus" aux-Memory        ;no consequence
1429
1430        ifelse (Defaulted-of ?)
1431          [ set aux-Memory lput "MY_Loss"     aux-Memory ] ;acknowledge loss
1432          [ set aux-Memory lput "PaidOnTime" aux-Memory ] ;acknowledge payment
1433        set aux-Memory lput "MyStatus"       aux-Memory   ;no event
1434        set aux-Memory lput QuotaWithInterestRate-of ? aux-Memory   ;current debt
1435        set aux-Memory lput aux-LoggedEventOrder       aux-Memory   ;order
1436
1437        ask ? [ set MeetingTrack lput aux-Memory MeetingTrack ]
1438        ;ask ? [ show "BAD INVESTOR MeetingTrack: " + MeetingTrack ];debug
1439
1440        set aux-Memory []
```

```
1441        set aux-LoggedEventOrder precision (aux-LoggedEventOrder + 0.1) 2
1442      ]
1443    ]
1444  end
1445  ;;;;;;;;;;;;;;;;  EVENTS  ;;;;;;;;;;;;;;;;
1446  ; go through all agents histories and update them
1447  ;
1448  to all-meeting-events
1449    locals [ aux-ProblematicClients aux-Problematic aux-Fine
1450             aux-Memory aux-VoteExpel ]
1451
1452    set aux-ProblematicClients [ ]
1453    set aux-Problematic [ ]
1454    set aux-Fine [ ]
1455    set aux-Memory [ ]
1456
1457    if (length aux-UniqueSickClients  > 0) [
1458      foreach aux-UniqueSickClients  [
1459        set aux-ProblematicClients lput ? aux-ProblematicClients ] ]
1460
1461    if (length aux-UniqueUnprofitable > 0) [
1462      foreach aux-UniqueUnprofitable [
1463        set aux-ProblematicClients lput ? aux-ProblematicClients ] ]
1464
1465    if (length aux-UniqueBadInvestors > 0) [
1466      foreach aux-UniqueBadInvestors [
1467        set aux-ProblematicClients lput ? aux-ProblematicClients ] ]
1468
1469    set aux-ProblematicClients remove-duplicates aux-ProblematicClients
1470    set aux-ProblematicClients sort aux-ProblematicClients
1471
1472    ;go through all clients and update their event histories
1473    foreach (shuffle aux-OrderedGroup)
1474    ;foreach aux-OrderedGroup
1475    [ ifelse not (member? ? aux-ProblematicClients) ;not a ProblematicClient
1476      [ ask ?
```

```
1477        [ without-interruption
1478          [ set aux-Fine lput ? aux-Fine
1479            ;show "aux-Fine: " + aux-Fine;debug
1480
1481            ;look for their data and put into the other clients
1482            foreach aux-ProblematicClients
1483            [ ;show "aux-ProblematicClients: " + aux-ProblematicClients;debug
1484
1485              foreach MeetingTrack-of ? ;an aux-ProblematicClients
1486              [ ;client misses meeting (item 3), not payment (item 4)
1487                if (item 3 ?) and not (item 4 ?) and (item 0 ? = aux-Repayment)
1488                [ ;show "Meeting: " + (item 0 ?) + ", Who: " + (item 1 ?) +
1489                  ;          ", TRUE  MissesMeeting: " + (item 2 ?) +
1490                  ;          ", FALSE Misses PAYMENT: " + (item 3 ?) ;debug
1491
1492                ;get relevant values: agent and meeting when that happened
1493                ;troubled meeting
1494                set aux-Problematic lput (item 0 ?) aux-Problematic
1495
1496                ;problematic agent
1497                set aux-Problematic lput (item 2 ?) aux-Problematic
1498                ;show "aux-Problematic:" + aux-Problematic ;debug
1499
1500                ;get data about the troubled agent in other agent histories
1501                ask item 0 aux-Fine ;only go through the current fine agent
1502                [ ; add the event, first timer
1503                  ifelse (length MeetingTrack-of (item 0 aux-Fine) = 0)
1504
1505                    ; client misses meeting, NOT payment
1506                    ; if this client has missed a payment, group
1507                    ; visit household (more pressure)
1508
1509                    ; if this client has NOT missed a payment before, group
1510                    ; leader visit household (less pressure)
1511                    ;   endorse POSITIVELY, if is sick
1512                    ;   endorse NEGATIVELY, if ISN'T sick
```

```
1513
1514                    [ ;show "EMPTY MEETINGTRACK: " + MeetingTrack-of
1515                      ;            item 0 aux-Fine + ", Agent: " + who;debug
1516
1517                      ; if this client has NOT missed a payment, group
1518                      ; leader visit household (less pressure)
1519
1520                      ;THIS ORDER IS VERY IMPORTANT to keep MeetingTrack
1521                      ;problematic meeting
1522                      set aux-Memory lput (item 0 aux-Problematic) aux-Memory
1523
1524                      ;who is the problem
1525                      set aux-Memory lput (item 1 aux-Problematic) aux-Memory
1526
1527                      ;who is storing data
1528                      set aux-Memory lput (item 0 aux-Fine) aux-Memory
1529
1530                      set aux-Memory lput MissedMeeting-of
1531                         (item 1 aux-Problematic) aux-Memory  ;missed meeting?
1532
1533                      set aux-Memory lput Defaulted-of
1534                        (item 1 aux-Problematic) aux-Memory  ;missed payment?
1535
1536                      set aux-Memory lput IsSick-of
1537                        (item 1 aux-Problematic) aux-Memory  ;is sick?
1538
1539                      set aux-Memory lput IsBadInvestor-of
1540                        (item 1 aux-Problematic) aux-Memory  ;bad investment?
1541
1542                      set aux-Memory lput IsUnprofitable-of
1543                        (item 1 aux-Problematic) aux-Memory  ;is unprofitable?
1544
1545                      set aux-Memory lput "LEADER_Visit" aux-Memory ;consequence
1546                      set aux-Memory lput "NO_Loss"      aux-Memory ;ack. it
1547
1548                      ;language, tolerance, debt,fine (aux-Run?)
```

```
1549                    ifelse ( ( (who-of item 0 aux-Fine) - 1 ) < 0 )
1550                      [ ifelse ( (item 1 (item 0 Tolerance-of
1551                                  (item 0 aux-Fine) ) ) = "tolerant")
1552                                 and ( IsSick-of (item 1 aux-Problematic) )
1553
1554                          [ set aux-Memory lput "Acceptable" aux-Memory ]
1555                          [ ifelse ( (item 1 (item 0 Tolerance-of
1556                                      (item 0 aux-Fine) ) ) = "tolerant")
1557
1558                              [set aux-Memory lput "Acceptable" aux-Memory]
1559                              [set aux-Memory lput "Unacceptable" aux-Memory]
1560                          ] ]
1561
1562                      [ ifelse (item 1 item ((who-of item 0 aux-Fine) - 1 )
1563                                Tolerance-of (item 0 aux-Fine) = "tolerant")
1564                               and ( IsSick-of (item 1 aux-Problematic) )
1565
1566                          [ set aux-Memory lput "Acceptable" aux-Memory ]
1567                          [ ifelse ( (item 1 (item 0 Tolerance-of
1568                                          (item 0 aux-Fine) ) ) = "tolerant")
1569
1570                              [set aux-Memory lput "Acceptable" aux-Memory]
1571                              [set aux-Memory lput "Unacceptable" aux-Memory]
1572                          ] ]
1573
1574                    set aux-Memory lput QuotaWithInterestRate-of
1575                        (item 1 aux-Problematic) aux-Memory ;current debt
1576
1577                    set aux-Memory lput aux-LoggedEventOrder aux-Memory ;order
1578                    ask (item 0 aux-Fine)
1579                      [ set MeetingTrack lput aux-Memory MeetingTrack ]
1580
1581                    ;ask (item 0 aux-Fine) [ show "event MeetingTrack: "
1582                    ;  + MeetingTrack ];debug
1583
1584                    set aux-Memory []
```

```
1585
1586                    set aux-LoggedEventOrder precision
1587                        (aux-LoggedEventOrder + 0.1) 2
1588                ]
1589
1590                ;look for the aux-Fine client database
1591                [ ;show "AUX_FINE: " + aux-Fine + "MEETINGTRACK_OF: " +
1592                  ;      MeetingTrack-of (item 0 aux-Fine);debug
1593
1594                  foreach MeetingTrack-of (item 0 aux-Fine)
1595                  [ ;found data about corresponding troubled agent
1596
1597                   ;same agent and missed past meeting, avoid empty entries
1598                    if (length ? != 0) and (
1599                        (item 1 ? = item 1 aux-Problematic) and (item 3 ?))
1600
1601                    [ ;show "FOUND problematic: " + ?;debug
1602                      set aux-Memory [ ]
1603
1604                      ; if this client has missed a payment before, all
1605                      ; group visit household (more pressure)
1606
1607                      ;THIS ORDER IS VERY IMPORTANT to keep MeetingTrack
1608                      set aux-Memory lput (item 0 aux-Problematic)
1609                            aux-Memory ;problematic meeting
1610
1611                      set aux-Memory lput (item 1 aux-Problematic)
1612                            aux-Memory ;who is the problem
1613
1614                      set aux-Memory lput (item 0 aux-Fine)
1615                            aux-Memory ;who is storing data
1616
1617                      set aux-Memory lput MissedMeeting-of ;missed meeting?
1618                           (item 1 aux-Problematic) aux-Memory
1619
1620                      set aux-Memory lput Defaulted-of ;missed payment?
```

```
1621                          (item 1 aux-Problematic) aux-Memory
1622
1623                        set aux-Memory lput IsSick-of
1624                          (item 1 aux-Problematic) aux-Memory  ;is sick?
1625
1626                        set aux-Memory lput IsBadInvestor-of
1627                          (item 1 aux-Problematic) aux-Memory  ;bad investor?
1628
1629                        set aux-Memory lput IsUnprofitable-of ;unprofitable?
1630                          (item 1 aux-Problematic) aux-Memory
1631
1632                        set aux-Memory lput "GROUP_Visit" aux-Memory ;conseq.
1633                        set aux-Memory lput "NO_Loss"    aux-Memory ;ack. it
1634
1635  ;                      ifelse ( IsSick-of (item 1 aux-Problematic) )
1636  ;                       [ set aux-Memory lput "Acceptable" aux-Memory ]
1637  ;                       [ set aux-Memory lput "Unacceptable" aux-Memory ]
1638
1639                        ;language, tolerance, debt,fine (aux-Run?)
1640                         ifelse ( ( (who-of item 0 aux-Fine) - 1 ) < 0 )
1641                           [ ifelse ( (item 1 (item 0 Tolerance-of (item 0 aux-
1642                                      and ( IsSick-of (item 1 aux-Problematic)
1643                                [ set aux-Memory lput "Acceptable" aux-Memory ]
1644                                [ ifelse ( (item 1 (item 0 Tolerance-of (item 0
1645                                 [set aux-Memory lput "Acceptable" aux-Memory]
1646                                 [set aux-Memory lput "Unacceptable" aux-Memory]
1647                                ] ]
1648
1649                           [ ifelse (item 1 item ((who-of item 0 aux-Fine)-1) T
1650                                    and ( IsSick-of (item 1 aux-Problematic) )
1651                                [ set aux-Memory lput "Acceptable" aux-Memory ]
1652                                [ ifelse ( (item 1 (item 0 Tolerance-of
1653                                           (item 0 aux-Fine) ) ) = "tolerant")
1654                                 [set aux-Memory lput "Acceptable" aux-Memory]
1655                                 [set aux-Memory lput "Unacceptable" aux-Memory]
1656                                ]
```

```
1657                                    ]
1658
1659                                set aux-Memory lput QuotaWithInterestRate-of
1660                                     (item 1 aux-Problematic) aux-Memory ;actual debt
1661
1662                                ;logged order
1663                                set aux-Memory lput aux-LoggedEventOrder aux-Memory
1664
1665                                ;set aux-Memory []
1666                                ;show "Found_Meeting: " + (item 0 ?)
1667                                ; + ", AnalysedClient: " + (item 1 ?)
1668                                ; + ", ProblematicMeeting: "+(item 0 aux-Problematic)
1669                                ; + ", ProblematicClient: " + (item 1 aux-Problematic)
1670                              ] ]
1671
1672                            ;to avoid repetitions of GROUP_VISIT events
1673                            ask (item 0 aux-Fine)
1674                              [ set MeetingTrack lput aux-Memory MeetingTrack ]
1675
1676                            set aux-LoggedEventOrder precision
1677                              (aux-LoggedEventOrder + 0.1) 2
1678
1679                            ; ask (item 0 aux-Fine)
1680                            ; [ show "event MeetingTrack: " + MeetingTrack ];debug
1681
1682                          ] ;end of searching aux-Fine's existing database
1683                        ] ;end of: "ask item 0 aux-Fine"
1684                    ]
1685
1686                    ; who missed meeting and payment for the first time
1687                    ;
1688                    if (item 3 ?) and (item 4 ?) and (item 0 ? = aux-Repayment)
1689                    [ ; show "Meeting: " + (item 0 ?) + ", Who: " + (item 1 ?)
1690                      ; + ", TRUE MissesMeeting: " + (item 2 ?)
1691                      ; + ", FALSE Misses PAYMENT: " + (item 3 ?) ;debug
1692
```

```
1693                ; get relevant data: agent and meeting when that happened
1694                set aux-Problematic lput (item 0 ?) aux-Problematic ;meeting
1695                set aux-Problematic lput (item 2 ?) aux-Problematic ;agent
1696                ;show "aux-Problematic:" + aux-Problematic ;debug
1697
1698                ;data about the troubled agent in other agent histories
1699                ask item 0 aux-Fine
1700                [ ifelse (length MeetingTrack-of (item 0 aux-Fine) = 0)
1701
1702                  ; add the event, first timer, client misses meeting AND
1703                  ; payment, if defaulter covered some loss OR has been
1704                  ; sick, cover this client loss, AND FINE if group formed
1705                  ; by neighbours in urban areas,  endorse, NEGATIVELY
1706                  ; DO NOT fine if group formed by family members in rural
1707                  ; areas, endorse POSITIVELY AND consider expelling, if
1708                  ; missed more than 1 payment, endorse NEGATIVELY
1709
1710                  ; if defaulter HAS NOT covered some loss OR HAS
1711                  ; NOT been sick, DO NOT cover this client loss AND
1712                  ; ADD MFI fine endorse NEGATIVELY
1713
1714                  ; IF missed more than X payments (individual tolerance),
1715                  ; vote for expelling (unacceptable event), if this client has
1716                  ; missed a payment before,  group visit household (more
1717                  ; pressure), if this client has NOT missed a payment before,
1718                  ; group leader visit household (less pressure)
1719                  ;     endorse POSITIVELY, if is sick
1720                  ;     endorse NEGATIVELY, if ISN'T sick
1721
1722                    [ ; show "EMPTY MEETINGTRACK: " + MeetingTrack-of
1723                      ; ? + ", Agent: " + who;debug
1724
1725                      ; if defaulter HAS NOT covered some loss OR HAS NOT
1726                      ; been sick, DO NOT cover this client loss AND ADD MFI
1727                      ; fine endorse NEGATIVELY
1728
```

```
1729                    ;THIS ORDER IS VERY IMPORTANT to keep MeetingTrack
1730                    set aux-Memory lput (item 0 aux-Problematic) aux-Memory
1731                    set aux-Memory lput (item 1 aux-Problematic) aux-Memory
1732                    set aux-Memory lput (item 0 aux-Fine) aux-Memory
1733
1734                    set aux-Memory lput MissedMeeting-of
1735                      (item 1 aux-Problematic) aux-Memory  ;missed meeting?
1736
1737                    ;set aux-Memory lput (item 3 MeetingTrack-of item 1
1738                    ;     aux-Problematic) aux-Memory  ;missed meeting?
1739
1740                    set aux-Memory lput Defaulted-of (item 1 aux-Problematic)
1741                        aux-Memory  ;missed payment?
1742
1743                    ;set aux-Memory lput (item 4 MeetingTrack-of item 1
1744                    ;     aux-Problematic) aux-Memory  ;missed payment?
1745
1746                    set aux-Memory lput IsSick-of (item 1 aux-Problematic)
1747                        aux-Memory  ;is sick?
1748
1749                    set aux-Memory lput IsBadInvestor-of
1750                      (item 1 aux-Problematic) aux-Memory  ;bad investor?
1751
1752                    set aux-Memory lput IsUnprofitable-of
1753                      (item 1 aux-Problematic) aux-Memory  ;is unprofitable?
1754
1755                    ;if defaulter has been sick, cover this client loss
1756                    ifelse (IsSick-of (item 1 aux-Problematic))
1757
1758                      [ ; look for Language, Location, Business
1759                        ; ifelse ( (item 2 Business-of (item 1 aux-Problematic
1760                        ; =  (item 2 Business-of (item 0 aux-Fine)) )
1761
1762                        ifelse ( ( (who-of item 1 aux-Problematic) - 1) = 0)
1763                          [ ifelse (item 1 item 0 Tolerance-of
1764                                   (item 0 aux-Fine) = "tolerant")
```

```
1765                                    [ ;show "SICK, FULLY COHESIVE Group."; debug
1766                                      set aux-Memory lput "SUPPORT" aux-Memory
1767                                      set aux-Memory lput "COVERED_Loss" aux-Memory
1768                                      set aux-Memory lput "Acceptable"
aux-Memory
1769                                    ]
1770
1771                                  [ set aux-Memory lput "PARTIAL_SUPPORT" aux-Memory
1772                                    set aux-Memory lput "GROUP_Fine" aux-Memory
1773                                    set aux-Memory lput "Unacceptable"   aux-Memory
1774                                  ] ]
1775
1776                                [ ifelse ( (item 0 Language-of
1777                                  (item 1 aux-Problematic)) = (item 0 Language-of
1778                                   (item 0 aux-Fine)) )
1779                                   [ set aux-Memory lput "PARTIAL_SUPPORT" aux-Memory
1780                                     set aux-Memory lput "GROUP_Fine" aux-Memory
1781                                     set aux-Memory lput "Unacceptable" aux-Memory
1782                                   ]
1783                                   [ set aux-Memory lput "MFI_Fine"    aux-Memory
1784                                     set aux-Memory lput "GROUP_Loss"  aux-Memory
1785                                     set aux-Memory lput "Unacceptable" aux-Memory
1786                                   ] ] ]
1787
1788                              ;problematic client is not sick
1789                               [ ;Language, Location is always the same, Business
1790                                 ;ifelse ( (item 0 Language-of
1791                                 ;  (item 1 aux-Problematic)) = (item 0 Language-of
1792                                 ;  (item 0 aux-Fine)) )
1793
1794                                 ifelse (item 1 item 0 Tolerance-of
1795                                        (item 0 aux-Fine) = "tolerant")
1796                                 [ ;if group is less cohesive
1797                                   ;show "NON-SICK, PARTIALLY COHESIVE Group."; debug
1798                                   set aux-Memory lput "PARTIAL_SUPPORT" aux-Memory
1799                                   set aux-Memory lput "GROUP_Fine" aux-Memory
```

```
1800                    set aux-Memory lput "Unacceptable" aux-Memory ]
1801
1802                    [ ;show "NON-SICK, NON-COHESIVE Group.";debug
1803                      set aux-Memory lput "MFI_Fine" aux-Memory
1804                      set aux-Memory lput "GROUP_Loss" aux-Memory
1805                      set aux-Memory lput "Unacceptable" aux-Memory
1806                    ] ]
1807
1808                  ; set aux-Memory lput QuotaWithInterestRate-of
1809                  ; (item 1 aux-Problematic) aux-Memory ;current debt
1810
1811                  ;configure new debts
1812                  ;show aux-Memory
1813                  ifelse (item 8 aux-Memory = "MFI_Fine")
1814                    [ set aux-Memory lput precision (
1815                       (QuotaWithInterestRate-of
1816                         (item 1 aux-Problematic)) * 2)
1817                        2 aux-Memory ;double
1818
1819                      ; + (((QuotaWithInterestRate-of
1820                      ; (item 1 aux-Problematic))
1821                      ; * InterestRate) / 100) ) 2 aux-Memory ;too low
1822
1823                      ; show "event debt: " + item 11 aux-Memory ;debug
1824                      set aux-TotalGroupDebt precision
1825                        (aux-TotalGroupDebt + item 11 aux-Memory) 2
1826
1827                      ; show "aux-TotalGroupDebt AFTER event: "
1828                      ; + aux-TotalGroupDebt;debug
1829
1830                      ;set MFI-Adviser aux-Memory
1831                      ask MFI_Adviser
1832                        [ set MeetingTrack lput aux-Memory MeetingTrack ]
1833
1834                    ] ;current debt
1835                    [ ifelse (item 9 aux-Memory = "GROUP_Fine")
```

```
1836                    [ set aux-Memory lput precision
1837                      ( (QuotaWithInterestRate-of
1838                        (item 1 aux-Problematic)) +
1839                         (QuotaWithInterestRate-of
1840                         (item 1 aux-Problematic)) / 2 ) 2 aux-Memory
1841
1842                      set aux-TotalGroupDebt precision
1843                        (aux-TotalGroupDebt + item 11 aux-Memory) 2
1844                    ] ;group fine as half of current debt
1845
1846                    [ set aux-Memory lput precision
1847                      (QuotaWithInterestRate-of
1848                        (item 1 aux-Problematic)) 2 aux-Memory
1849                    ] ]
1850
1851                  set aux-Memory lput aux-LoggedEventOrder aux-Memory
1852                  ; ask (item 0 aux-Fine) [
1853                  ; set MeetingTrack lput aux-Memory MeetingTrack ]
1854
1855                  ; ask (item 0 aux-Fine)
1856                  ; [ show "event MeetingTrack: " + MeetingTrack ];debug
1857
1858                  ; set aux-Memory []
1859                  ; set aux-LoggedEventOrder precision
1860                  ; (aux-LoggedEventOrder+ 0.1) 2
1861
1862                ] ;deal with 1st timers: MFI_Fine, GROUP_Fine, COVER_Loss
1863
1864
1865              ;consider expelling if missed > 1 payment, endorse NEGATIVELY
1866              ; if defaulter covered some loss, cover this client loss
1867              ; IF missed more than X payments (individual tolerance), vote
1868              ; expelling (unacceptable event)
1869
1870              ; if this client has missed a payment before, all
1871              ; group visit household (more pressure)
```

```
1872                    ; if this client has NOT missed a payment before, group
1873                    ; leader visit household (less pressure)
1874
1875                    ;look for the aux-Fine client database
1876                    [ ;show "MT: " + MeetingTrack-of (item 0 aux-Fine);debug
1877
1878                      foreach MeetingTrack-of (item 0 aux-Fine)
1879                      [ ;found the data about the corresponding problematic agent
1880
1881                        ;same agent and has covered some loss
1882                        ifelse  (length ? != 0) and
1883                                    ((item 1 ? = item 1 aux-Problematic)
1884                                    and (item 9 ? = "COVERED_Loss") )
1885                        [ ;show "FOUND problematic: " + ?;debug
1886
1887                        ; if this client has missed a payment before, group visit
1888
1889                        ;THIS ORDER IS VERY IMPORTANT to keep MeetingTrack
1890                        set aux-Memory lput (item 0 aux-Problematic) aux-Memory
1891                        set aux-Memory lput (item 1 aux-Problematic) aux-Memory
1892                        set aux-Memory lput (item 0 aux-Fine)        aux-Memory
1893
1894                        set aux-Memory lput MissedMeeting-of
1895                          (item 1 aux-Problematic) aux-Memory  ;missed meeting?
1896
1897                         set aux-Memory lput Defaulted-of
1898                           (item 1 aux-Problematic) aux-Memory  ;missed payment?
1899
1900                        set aux-Memory lput IsSick-of
1901                          (item 1 aux-Problematic) aux-Memory
1902
1903                        set aux-Memory lput IsBadInvestor-of
1904                          (item 1 aux-Problematic) aux-Memory  ;bad investor?
1905
1906                       set aux-Memory lput IsUnprofitable-of
1907                         (item 1 aux-Problematic) aux-Memory  ;is unprofitable?
```

```
1908
1909                    set aux-Memory lput "COVER_Loss" aux-Memory ;consequence
1910                        set aux-Memory lput "NO_Loss"     aux-Memory ;ack. it
1911
1912
1913 ;                        ifelse ( IsSick-of (item 1 aux-Problematic) )
1914 ;                        [ set aux-Memory lput "Acceptable" aux-Memory ]
1915 ;                        [ set aux-Memory lput "Unacceptable" aux-Memory ]
1916
1917                        ;language, tolerance, debt,fine (aux-Run?)
1918                        ifelse ( ( (who-of item 0 aux-Fine) - 1 ) < 0 )
1919                          [ ifelse ( (item 1 (item 0 Tolerance-of
1920                             (item 0 aux-Fine) ) ) = "tolerant")
1921                                    and ( IsSick-of (item 1 aux-Problematic) )
1922                            [set aux-Memory lput "Acceptable" aux-Memory]
1923                            [ifelse ( (item 1 (item 0 Tolerance-of
1924                              (item 0 aux-Fine) ) ) = "tolerant")
1925                              [set aux-Memory lput "Acceptable" aux-Memory]
1926                              [set aux-Memory lput "Unacceptable" aux-Memory]
1927                            ] ]
1928
1929                          [ ifelse (item 1 item ((who-of item 0 aux-Fine)-1)
1930                            Tolerance-of (item 0 aux-Fine) = "tolerant")
1931                                  and ( IsSick-of (item 1 aux-Problematic) )
1932                            [ set aux-Memory lput "Acceptable" aux-Memory ]
1933                            [ ifelse ( (item 1 (item 0 Tolerance-of
1934                              (item 0 aux-Fine) ) ) = "tolerant")
1935                              [set aux-Memory lput "Acceptable" aux-Memory]
1936                              [set aux-Memory lput "Unacceptable" aux-Memory]
1937                            ] ]
1938
1939                        set aux-Memory lput QuotaWithInterestRate-of
1940                          (item 1 aux-Problematic) aux-Memory ;current debt
1941
1942                        set aux-Memory lput aux-LoggedEventOrder aux-Memory
1943                        ask (item 0 aux-Fine)
```

```
1944                          [ set MeetingTrack lput aux-Memory MeetingTrack ]
1945                          ; ask (item 0 aux-Fine)  ;debug
1946                          ; [ show "event MeetingTrack: " + MeetingTrack ]
1947
1948                        set aux-Memory []
1949                        set aux-LoggedEventOrder precision
1950                          (aux-LoggedEventOrder + 0.1) 2
1951
1952                        ; show "Found meeting: " + (item 0 ?) +
1953                        ;   ", client: " + (item 1 ?) + ", Troubled Meeting: "
1954                        ; + (item 0 aux-Problematic) + ", Agent: " +
1955                        ; + (item 1 aux-Problematic)
1956                      ] ;dealt with COVER_Loss
1957
1958
1959                    ;client has not covered any loss
1960                    [ ;avoid copying events when scanning client's history
1961                      if (aux-VoteExpel = "init")
1962                      [ ;THIS ORDER IS VERY IMPORTANT to keep MeetingTrack
1963                        set aux-Memory [ ]
1964                        ;problematic meeting
1965                        set aux-Memory lput (item 0 aux-Problematic) aux-Memory
1966
1967                        ;who is the problem
1968                        set aux-Memory lput (item 1 aux-Problematic) aux-Memory
1969
1970                        ;who is storing data
1971                        set aux-Memory lput (item 0 aux-Fine) aux-Memory
1972
1973                        set aux-Memory lput MissedMeeting-of
1974                           (item 1 aux-Problematic) aux-Memory
1975
1976                        ;missed meeting?
1977                        set aux-Memory lput Defaulted-of
1978                          (item 1 aux-Problematic) aux-Memory  ;missed payment?
1979
```

```
1980                    set aux-Memory lput IsSick-of
1981                      (item 1 aux-Problematic) aux-Memory  ;is sick?
1982
1983                    set aux-Memory lput IsBadInvestor-of
1984                      (item 1 aux-Problematic) aux-Memory  ;bad investor?
1985
1986                    set aux-Memory lput IsUnprofitable-of
1987                     (item 1 aux-Problematic) aux-Memory  ;unprofitable?
1988
1989                    set aux-Memory lput "VOTE_Expel" aux-Memory ;conseq.
1990                    set aux-Memory lput "AVOID_Loss" aux-Memory ;ack. it
1991
1992  ;                 ifelse ( IsSick-of (item 1 aux-Problematic) )
1993  ;                   [set aux-Memory lput "Acceptable" aux-Memory]
1994  ;                   [set aux-Memory lput "Unacceptable" aux-Memory]
1995
1996                    ;language, tolerance, debt,fine (aux-Run?)
1997                    ifelse ( ( (who-of item 0 aux-Fine) - 1 ) < 0 )
1998                     [ ifelse ( (item 1 (item 0 Tolerance-of
1999                         (item 0 aux-Fine) ) ) = "tolerant")
2000                          and ( IsSick-of (item 1 aux-Problematic) )
2001                       [set aux-Memory lput "Acceptable" aux-Memory]
2002                       [ifelse ( (item 1 (item 0 Tolerance-of
2003                        (item 0 aux-Fine) ) ) = "tolerant")
2004                          [set aux-Memory lput "Acceptable"   aux-Memory]
2005                          [set aux-Memory lput "Unacceptable" aux-Memory]]]
2006
2007                     [ ifelse (item 1 item ((who-of item 0 aux-Fine) - 1 )
2008                        Tolerance-of (item 0 aux-Fine) = "tolerant")
2009                         and ( IsSick-of (item 1 aux-Problematic) )
2010                       [set aux-Memory lput "Acceptable" aux-Memory]
2011                       [ifelse ( (item 1 (item 0 Tolerance-of
2012                         (item 0 aux-Fine) ) ) = "tolerant")
2013                           [set aux-Memory lput "Acceptable"   aux-Memory]
2014                           [set aux-Memory lput "Unacceptable" aux-Memory]]]
2015
```

```
2016
2017                    set aux-Memory lput QuotaWithInterestRate-of
2018                      (item 1 aux-Problematic) aux-Memory ;current debt
2019
2020                    set aux-Memory lput aux-LoggedEventOrder aux-Memory
2021                    ;show "aux-Memory: " + aux-Memory; debug
2022                    set aux-VoteExpel "done"]]]]; dealt with non-1st timers
2023
2024                ifelse not (empty? aux-Memory)
2025                  [ ask (item 0 aux-Fine)
2026                    [ set MeetingTrack lput aux-Memory MeetingTrack ]
2027                    set aux-LoggedEventOrder precision
2028                      (aux-LoggedEventOrder + 0.1) 2
2029                    set aux-VoteExpel "init"
2030                  ]
2031
2032                  [ ;THIS ORDER IS VERY IMPORTANT to keep MeetingTrack
2033
2034                    set aux-Memory [ ]
2035                    set aux-Memory lput (item 0 aux-Problematic) aux-Memory
2036                    set aux-Memory lput (item 1 aux-Problematic) aux-Memory
2037                    set aux-Memory lput (item 0 aux-Fine) aux-Memory
2038
2039                    set aux-Memory lput MissedMeeting-of
2040                      (item 1 aux-Problematic) aux-Memory  ;missed meeting?
2041
2042                    set aux-Memory lput Defaulted-of
2043                      (item 1 aux-Problematic) aux-Memory  ;missed payment?
2044
2045                    set aux-Memory lput IsSick-of
2046                      (item 1 aux-Problematic) aux-Memory  ;is sick?
2047
2048                    set aux-Memory lput IsBadInvestor-of
2049                      (item 1 aux-Problematic) aux-Memory  ;bad investment?
2050
2051                    set aux-Memory lput IsUnprofitable-of
```

```
2052                    (item 1 aux-Problematic) aux-Memory  ;is unprofitable?
2053
2054                  ifelse ( ( (who-of item 0 aux-Fine) - 1 ) < 0 )
2055                    [ ifelse ( (item 1 (item 0 Tolerance-of
2056                      (item 0 aux-Fine) ) ) = "tolerant")
2057                        [ set aux-Memory lput "COVER_Loss" aux-Memory
2058                          set aux-Memory lput "NO_Loss"    aux-Memory
2059                          set aux-Memory lput "Acceptable" aux-Memory
2060                        ] ;acknowledge it
2061
2062                        [ set aux-Memory lput "VOTE_Expel"  aux-Memory
2063                          set aux-Memory lput "AVOID_Loss"  aux-Memory
2064                          set aux-Memory lput "Unacceptable" aux-Memory
2065                        ] ;acknowledge it
2066                    ]
2067                    [ ifelse (item 1 item ((who-of item 0 aux-Fine)-1)
2068                      Tolerance-of (item 0 aux-Fine) = "tolerant")
2069                        [ set aux-Memory lput "COVER_Loss" aux-Memory
2070                          set aux-Memory lput "NO_Loss"    aux-Memory
2071                          set aux-Memory lput "Acceptable" aux-Memory
2072                        ] ;acknowledge it
2073
2074                        [ set aux-Memory lput "VOTE_Expel"  aux-Memory
2075                          set aux-Memory lput "AVOID_Loss"  aux-Memory
2076                          set aux-Memory lput "Unacceptable" aux-Memory
2077                        ] ;acknowledge it
2078                    ]
2079
2080                  set aux-Memory lput QuotaWithInterestRate-of
2081                    (item 1 aux-Problematic) aux-Memory ;current debt
2082
2083                  set aux-Memory lput aux-LoggedEventOrder
2084                    aux-Memory ;logged order
2085
2086                  ;show "aux-Memory: " + aux-Memory;debug
2087                  ask (item 0 aux-Fine)
```

```
2088                              [ set MeetingTrack lput aux-Memory MeetingTrack ]
2089
2090                            set aux-LoggedEventOrder precision
2091                              (aux-LoggedEventOrder + 0.1) 2
2092                          ]
2093
2094                        ;ask (item 0 aux-Fine)
2095                        ;  [ show "event MeetingTrack: " + MeetingTrack ];debug
2096                        set aux-Memory []
2097
2098                    ] ;end of first timer of who missed meeting and payment
2099                  ] ]
2100
2101                set aux-Problematic [ ];to avoid repetitions
2102              ]
2103              set aux-Fine [ ] ;to correct next iteration
2104            ] ] ]
2105
2106      ;agent is part of problematic group
2107      [ ;show ? + ", part of troubled group in MEETING: " + aux-Repayment;debug
2108  ;
2109  ;       ;THIS ORDER IS VERY IMPORTANT to keep MeetingTrack correct
2110  ;       set aux-Memory lput aux-Run aux-Memory                ;problematic meeting
2111  ;       set aux-Memory lput who-of ? aux-Memory               ;who is the problem
2112  ;       set aux-Memory lput who-of ? aux-Memory               ;who is storing data
2113  ;       set aux-Memory lput MissedMeeting-of  ? aux-Memory    ;missed meeting?
2114  ;       set aux-Memory lput Defaulted-of      ? aux-Memory    ;missed payment?
2115  ;       set aux-Memory lput IsSick-of         ? aux-Memory    ;is sick?
2116  ;       set aux-Memory lput IsBadInvestor-of  ? aux-Memory    ;bad investor?
2117  ;       set aux-Memory lput IsUnprofitable-of ? aux-Memory    ;is unprofitable?
2118  ;       set aux-Memory lput "xxxxx" aux-Memory                ;consequence
2119  ;       set aux-Memory lput "xxxxx" aux-Memory                ;acknowledge it
2120  ;       set aux-Memory lput "xxxxx" aux-Memory                ;x
2121  ;       set aux-Memory lput QuotaWithInterestRate-of ? aux-Memory ;current debt
2122  ;       set aux-Memory lput aux-LoggedEventOrder aux-Memory ;logged order
2123  ;
```

```
2124 ;       set aux-Memory []
2125 ;       set aux-LoggedEventOrder precision (aux-LoggedEventOrder + 0.1) 2
2126 ;
2127 ;       ask ? [ set MeetingTrack lput aux-Memory MeetingTrack ]
2128     ]
2129   ]
2130
2131   meeting_decision ;record a decision
2132 end
2133
2134 ;;;;;;;;;;;;;;; MEETING_DECISION ;;;;;;;;;;;;;;;;;;;;;;;;;;
2135 ;
2136 ; simply counts and keep track of all meeting results
2137 ;
2138 to meeting_decision
2139   ; count GROUP_Loss (MFI_Fine,  VOTE_Expel ),
2140   ; GROUP_Fine (PARTIAL_SUPPORT)
2141   foreach aux-OrderedGroup
2142   [ foreach MeetingTrack-of ?
2143     [ if (length ? != 0) ;to avoid empty entries
2144       [ if (item 0 ? = aux-Repayment)
2145         [ ;acceptable events
2146
2147   if (item 8 ?="PARTIAL_SUPPORT")
2148    [set aux-TotalPartialSupport aux-TotalPartialSupport+1]
2149
2150   if (item 8 ? = "LEADER_Visit")
2151     [set aux-TotalLeaderVisit aux-TotalLeaderVisit+1]
2152
2153   if (item 8 ? = "SUPPORT") [set aux-TotalSupport aux-TotalSupport+1]
2154   if (item 8 ? = "GROUP_Visit") [set aux-TotalGroupVisit aux-TotalGroupVisit+1]
2155   if (item 8 ? = "COVER_Loss") [set aux-TotalCoverLoss aux-TotalCoverLoss+1]
2156   if (item 9 ? = "COVERED_Loss") [set aux-TotalCoverLoss aux-TotalCoverLoss+1]
2157   if (item 9 ? = "NO_Loss") [set aux-TotalNoLoss aux-TotalNoLoss+1]
2158   if (item 10 ? = "Acceptable") [set aux-TotalDesirable aux-TotalDesirable+1]
2159
```

```
2160     ;situation per meeting
2161     if (item 3 ?) [ set aux-TotalMissedMeetings aux-TotalMissedMeetings + 1 ]
2162     if (item 4 ?) [ set aux-TotalMissedPayments aux-TotalMissedPayments + 1 ]
2163     if (item 5 ?) [ set aux-TotalSickClients aux-TotalSickClients    + 1 ]
2164     if (item 6 ?) [ set aux-TotalBadInvestors aux-TotalBadInvestors  + 1 ]
2165     if (item 7 ?) [ set aux-TotalUnprofitable aux-TotalUnprofitable  + 1 ]
2166
2167     ;unacceptable events
2168     if (item 8 ? = "VOTE_Expel") [set aux-TotalVoteExpel  aux-TotalVoteExpel+1]
2169     if (item 8 ? = "MFI_Fine") [set aux-TotalMFI_Fine   aux-TotalMFI_Fine + 1]
2170     if (item 9 ? = "MY_Loss")  [ set aux-TotalMyLoss    aux-TotalMyLoss + 1]
2171     if (item 9 ? = "GROUP_Fine") [set aux-TotalGroupFine  aux-TotalGroupFine+1]
2172     if (item 9 ? = "GROUP_Loss") [set aux-TotalGroupLoss  aux-TotalGroupLoss+1]
2173     if (item 9 ? = "PaidOnTime") [set aux-TotalPaidOnTime aux-TotalPaidOnTime+1]
2174     if (item 9 ? = "AVOID_Loss") [set aux-TotalAvoidLoss  aux-TotalAvoidLoss+1]
2175 if (item 10 ? = "Unacceptable") [set aux-TotalUndesirable aux-TotalUndesirable+1
2176
2177           if (Plots) [
2178             set-current-plot "Events as-it-happens"
2179             set-current-plot-pen "LeaderVisit"
2180             plot aux-TotalLeaderVisit
2181
2182             set-current-plot-pen "GroupVisit"
2183             plot aux-TotalGroupVisit
2184
2185             set-current-plot-pen "CoveredLosses"
2186             plot aux-TotalCoverLoss
2187
2188             set-current-plot-pen "TotalSupport"
2189             plot aux-TotalSupport
2190
2191             set-current-plot-pen "ExpellingVotes"
2192             plot aux-TotalVoteExpel
2193
2194             set-current-plot-pen "TotalFines"
2195             plot (aux-TotalMFI_Fine + aux-TotalGroupFine) ]
```

```
2196
2197          ;write evolution of events per simulation
2198          if (WriteToFile) [
2199          file-type ", " + aux-TotalLeaderVisit + ", "  + aux-TotalGroupVisit
2200                        + ", " +  aux-TotalGroupVisit  + ", "
2201
2202          file-print aux-TotalSupport     + ", " + aux-TotalVoteExpel  + ", "
2203                        + (aux-TotalMFI_Fine + aux-TotalGroupFine)
2204          ] ] ] ] ]
2205  end
2206
2207  ;;;;;;;;;;;;;;;;;  MEETING  ;;;;;;;;;;;;;;;;;
2208  ;
2209  ; set what happens before, during and after a meeting
2210  ;
2211
2212  to meeting
2213    locals [ aux-i aux-j  aux-Tolerance aux-Debt ProblemsOrder]
2214    set aux-i 0
2215    set aux-j 0
2216    set ProblemsOrder ["diseases"  "unprofitable"  "badinvestor"]
2217
2218
2219    ;write all first values
2220    if (aux-Repayment = 0) [
2221      while [aux-i < MFI-Group]
2222        [ set aux-Tolerance (value-from item aux-i aux-OrderedGroup [Tolerance])
2223          set aux-i aux-i + 1
2224          set aux-Repayment aux-Repayment + 1
2225        ]
2226      set aux-Repayment 0
2227      stop  ]
2228
2229    set  ProblemsOrder shuffle ProblemsOrder
2230
2231    ;in this way, events are given after ALL differently ordered problems
```

```
2232    if (ProblemsOrder = ["diseases" "unprofitable" "badinvestor"] ) [
2233      if (WriteToFile) [ file-type "Dis  Unp  BIn" ]
2234      setup-defaulting-disease-influence        diseases
2235      setup-defaulting-unprofitable-influence   unprofitable
2236      setup-defaulting-investment-influence     badinvestor
2237      set aux-DisUnpBIn aux-DisUnpBIn + 1     ]
2238
2239    if (ProblemsOrder = ["diseases" "badinvestor" "unprofitable"] ) [
2240      if (WriteToFile) [ file-type "Dis  BIn  Unp" ]
2241      setup-defaulting-disease-influence        diseases
2242      setup-defaulting-investment-influence     badinvestor
2243      setup-defaulting-unprofitable-influence   unprofitable
2244      set aux-DisBInUnp aux-DisBInUnp + 1    ]
2245
2246    if (ProblemsOrder = ["unprofitable" "diseases" "badinvestor"] ) [
2247      if (WriteToFile) [ file-type "Unp  Dis  BIn" ]
2248      setup-defaulting-unprofitable-influence   unprofitable
2249      setup-defaulting-disease-influence        diseases
2250      setup-defaulting-investment-influence     badinvestor
2251      set aux-UnpDisBIn aux-UnpDisBIn + 1     ]
2252
2253    if (ProblemsOrder = ["unprofitable" "badinvestor" "diseases"] ) [
2254      if (WriteToFile) [ file-type "Unp  BIn  Dis" ]
2255      setup-defaulting-unprofitable-influence   unprofitable
2256      setup-defaulting-investment-influence     badinvestor
2257      setup-defaulting-disease-influence        diseases
2258      set aux-UnpBInDis aux-UnpBInDis + 1   ]
2259
2260    if (ProblemsOrder = ["badinvestor" "unprofitable" "diseases"] ) [
2261      if (WriteToFile) [ file-type "BIn  Unp  Dis" ]
2262      setup-defaulting-investment-influence     badinvestor
2263      setup-defaulting-unprofitable-influence   unprofitable
2264      setup-defaulting-disease-influence        diseases
2265      set aux-BInUnpDis aux-BInUnpDis + 1    ]
2266
2267    if (ProblemsOrder = ["badinvestor" "diseases" "unprofitable"] ) [
```

```
2268      if (WriteToFile) [ file-type "BIn  Dis  Unp" ]
2269      setup-defaulting-investment-influence     badinvestor
2270      setup-defaulting-disease-influence        diseases
2271      setup-defaulting-unprofitable-influence   unprofitable
2272      set aux-BInDisUnp aux-BInDisUnp + 1  ]
2273
2274    ;if (WriteToFile) [ file-print "MPPM:,  " + aux-PossibleProblematicMeetings ]
2275    ;if (aux-PossibleProblematicMeetings > 0 )
2276      [ show "aux-PossibleProblematicMeetings: "+aux-PossibleProblematicMeetings]
2277        ;debug
2278
2279
2280       ;keep writing the transformations
2281       while [aux-i < MFI-Group] [ ;go through all list items
2282                ;initialise aux-Tolerance
2283                set aux-Tolerance (value-from item
2284                  aux-i aux-OrderedGroup [Tolerance])
2285      set aux-i aux-i + 1 ;go on
2286    ]
2287  end
```

7.7 Appendix VII: Simulation User Guide

How To Guide (Spanish version 07 June 2009, English version reviewed on 15 May 2010)

Pablo Lucas, Centre for Policy Modelling, Manchester, England. pablo@cfpm.org

1 Introduction

The simulation model is available at http://cfpm.org/~pablo/MCModel and was developed using data collected in four surveys and one fieldwork administered in Chiapas, southern Mexico. The first three surveys were most useful to guide what should be modelled and realistic parameters' ranges. The last survey was mainly used to better understand and justify certain assumptions taken regarding individual behaviour within microfinance groups. Following sections briefly explain how to configure and interpret data obtained in simulation runs.

2 Configuring and executing simulations

As described in the Spanish manual written for the MFI directors, once loaded the simulation interface contains 8 graph areas and 12 possible configurations available. Tables 1, 2 and 3 below show all parameters, whilst Table 4 in next section synthesises what and how data is presented.

Property	Description	Range
Rural	True for a rural group, otherwise urban	Boolean
MFI-Group	How many participants in a simulated group?	3 to 7
Bad-Investors	How many people can be affected by bad investments?	0 to 7
Unprofitable	How many people can be affected by non-profitable activities?	0 to 7
Disease-Incidence	What is the percentage of people and payments that can be subject to disease?	0% to 100%

Table 1: Configuring the circumstances of a group

All possible parameter's range are: MFI-Group between 3 to 7 (according to group size distribution findings), 12 or 24 payments (the two options provided by them), rural or urban, number of unprofitable clients (0 to 7), bad investors (0 to 7) and disease incidence (0 to 100% in intervals of 10). Respectively that means there are 5, 2, 2, 8, 8 and 11 possible configurations per parameter. All conceivable combinations amount to 14.080 options, without considering financial parameters. The latter, as listed in Table 2, includes: interest rates (from 0.5 to 3.5 in intervals of 0.5), minimum and maximum debts (from 1000 to 40.000 in intervals of 1000), equal or unequal credit distribution. Sweeping through all parameters is impractical and unnecessary, as many combinations are realistic. For instance the more unprofitable or bad investors added to a simulation, the bigger the microcredit group must become to allow coping opportunities; thus reducing the number of testable parameters. Additionally configurations can be mutually exclusive. I.e., it is not possible to have a micro-finance group in this simulation model whereby all members are highly problematic. Groups alike in reality are most likely to fail and evidence shows that this is an unusual and undesirable situation for micro-financiers, which is often amended by the corresponding institution before such groups receives credit.

As previously said, the group size can impact directly in the simulation results. This happens as the more agents log their decisions, the more likely these will change results regarding their votes and events. These, of course, relate to missed meeting and/or payments. MFI-Group, Bad-Investors, Unprofitable and Disease-Incidence in Table 1, along with Repayments in Table 2, influences the total number of events that can be logged in the simulation results. This happens as individual outcomes depend on the quantity of people, potential problems affecting them, meetings to attend and quotas to be paid.

Property	Description
InterestRate	Interest rate for the total individual debt
EqualCredit	Will all participants deal with the same amount of credit or not? (Boolean)
MaxAgentDebt	Maximum individual debt, in case credit is not uniformly distributed
MinAgentDebt	Minimum individual debt, in case credit is not uniformly distributed
Repayments	How many meetings, and therefore outstanding quotas, each person has?

Table 2: Financial configurations

If EqualCredit is off, financial properties might affect participants in different ways, as if an individual with higher debt eventually misses a payment, covering that without penalisations is presumably more difficult. However, as there is no evidence as to how much, or which threshold, clients change their behaviour, assessing the feasibility of such logged actions are left to the end user. Choosing an uneven credit distribution means debts will be allocated randomly between the range of MinAgentDebt and MaxAgentDebt. The MFI itself has only recently started with this uneven credit modality and do not yet have enough experience with regards to how clients generally behave in this new scheme. Each simulation

generates a detailed log of what all clients decided about a problematic event during their credit cycle. Thus, depending on the set configurations like debt range, one might understand certain logged actions as plausible or not. This cannot be automatically added in the model without biasing the simulated behaviour, as at some point the modeller must define a hypothetical threshold and there is no known reliable evidence on this regard. If EqualCredit is set true, all clients will get the same amount of debt having 33% of MaxAgentDebt, according to the significantly most frequent of all financial criteria analysed in the financial data presented in the second report. The last configurable properties in Table 3 control the mechanical properties of the model. These include determining the initial state of the simulation (Init), whether the user wants to visualise graphs being updated (Plots) whilst Iterations are being executed (Go).

Property	Description
Plots	Update all interface graphs at runtime
Init	Initialise the model with all selected configuration parameters
Iterations	How many times the model will be executed with the same configuration?
Go	Execute simulations, plotting data graphically or simply writing it to a file

Table 3: Configurations regarding the simulation process itself

If the model is configured without any exogenous or endogenous problems affecting participants, the only possible result from simulations is a continuum of micro-credit groups classified as having equal number (zero) for desirable and undesirable events. Such individual registering is only triggered in light of a group member missing a meeting or payment. This happens as it is assumed that, without any negative interference, groups are most likely to succeed over time. Of course this is not always the case in reality, but without adding any known negative influence to the model – gathered during this case study's fieldwork, nothing relevant from clients sanctions and decisions can be processed or logged at simulation runtime. Financial aspects such as interest rate, equal credit distribution, minimum and maximum individual debts are only relevant for interpretation purposes, as the simulation model only keeps track of social behaviour amongst group participants and annotates relevant financial aspects in it. When social behaviour in this model has a monetary dimension, such as groups or institutional fines, assessing whether a particular sanction or support action is a feasible outcome is an end-user task. In other words, the stakeholder, researcher or policy-maker using the model should interpret that. Although possible, adding an automatic evaluation of these in the simulation would considerably bias and therefore change simulation results. It would also complicate interpreting data generated by the model, as then the simulation would not be exclusively based on consistent evidence acquired in fieldwork. Instead, there would be an unfounded influence introduced by the modeller which end-users would not be able to identify in obtained results. This is important as this model was purposely built and driven only by using available evidence. Evidence seems to suggest greater behaviour variability between those with unequal credit distribution, yet this can only be understood as a conjecture drawn from what has been observed.

3 Interpreting Results

Every simulation generates outputs for groups with more desirable events, more undesirable events and equal number of those. It is not possible to precisely assess whether groups are successful or not, as simulation results rather imply their likelihood of failing or succeeding by how the group dynamics evolved during the simulations. In June 7th 2009 the simulation model, along with a short manual, was made available online to the MFI director for testing purposes. That document contains a brief description how the model can be used and interpreted, skipping all technical details in it to focus solely on their experience as users. The model is accessible via Web featuring a Java applet with all configurable properties and graphs that are updated at runtime. Few days after contacting the MFI director, the third fieldwork report containing findings from the fourth and last questionnaire to officers was presented to the MFI and research partners.

Each time a simulation is run, there is a detailed report of which configurations were used, time-series of all individual events during credit cycles and a summary of the most important data in it. Even before testing the simulation, it is possible to understand that some configurations can play a significant role in how results are obtained. For instance, the group size and number of repayments are directly linked to how many opportunities clients will have to face a problem and log a decision about it. If both the group size and number of repayments are configured lowly, say unrealistically both set as 3, results will differ a lot from other simulation runs with more participants and longer deadlines simply as the number of analysed individual events will change substantially. In this sense, it is better to analyse a handful of potentially interesting parameters instead of all possible combinations.

3 Graphs

Those entitled Elapsed Time and Individual Debts show the dispersion of their corresponding data to help understanding the variability occurring between simulations because tend to visually cluster over time. All the other graphs display the totals of every type of individually logged event that is described in the simulation. Depending on the quantity of registered events, by all group members, data will be displayed in the corresponding graphs. That is, in Desirable, Undesirable or Equal (in case there is exactly the same number of both events types).

Graph	Presented data
Total group outcomes	Desirable, Undesirable, Equal (number of simulations that fall within each category)
Equal group events	LeaderVisit, GroupVisit, CoveredLosses, TotalSupport, ExpellingVotes, TotalFines (totals)
Desirable group events	LeaderVisit, GroupVisit, CoveredLosses, TotalSupport, ExpellingVotes, TotalFines (totals)
Undesirable group events	LeaderVisit, GroupVisit, CoveredLosses, TotalSupport, ExpellingVotes, TotalFines (totals)
Elapsed time	Timer (how long each simulation took to be completed)
Individual debts	PersonalDebt, QuotaWithInterestRate (distribution of debts and quotas to be paid)

Table 4: Simulation data presented in each graph

It is not possible to determine with precision whether groups with more Desirable events actually had financial and social success, and that those with more Undesirable ones failed. This is uncertain as the criteria for this type of interpretation is very particular to the real circumstances of each microfinance group. The simulation model presented hereby can only suggest that groups presented in the Desirable graph have greater likelihood of achieving social and financial success. In these cases, according to their initial configuration and evolution till the end of their credit cycle, clients have presumably dealt with their problems in a more similar way to the characterisation of successful groups presented in the first and second fieldwork reports.

The LeaderVisit occurs when a client missed a meeting for the first time, but has paid her quota. According to the first fieldwork findings, presented in the first report, this is the most common action in such occasions. Usually the group representative visits the affected person and regards this fact positively if the affected person is sick, otherwise negatively. GroupVisit events are registered only after the group member in question has already missed payments during the same credit cycle. TotalSupport event accounts to two different types of support available within groups. That is, those indicading CoveredLosses that can be a PARTIAL_SUPPORT event (which includes group fines) and SUPPORT in case there has been enough tolerance to waive collective fines. Fines usually do not appear in the graphs are these are generally rare events, only occurring occasionally due to their strong impact. The model contains in total 24 types of events, but not all them are necessary to interpret results in graphs, as many of these are auxiliary to the 6 chosen most representative events for analysing the generated data (LeaderVisit, GroupVisit, CoveredLosses, TotalSupport, ExpellingVotes, TotalFines). The complete list of events consists of: ElapsedTime, Run, #Events, Final Status, #Desirable, #Undesirable, #LEADER_Visit, #GROUP_Visit, #COVER_Loss, #NO_Loss, #PaidOnTime, #MyLoss, #AVOID_Loss, #Full_Support, #Missed Meetings, #Missed Payments, #ExpelVote, #MFIFine, #GroupFine, #GroupLoss, #PartialSupport, #EventsWithSickClients, #EventsWithBadInvestors and #EventsWithUnprofitable.

4 Possible Extentions

The model configures groups with properties such as their language, type of business and their location. Simulated groups are automatically associated with one of the following places, extracted from the Mexican IRIS Geographical Information System: Palenque, Zinacantan, Yajalon, Tila, Teopisca, Salto de Agua, Pantelho, Larrainzar, La Libertad, Ixtapa, Escuintla, Chilon, Chenalho, Catazaja, Jitotol, Pueblo Nuevo, Chiapa de Corzo, Motozintla de Mendoza, Pueblo Nuevo Solistahuacan, San Cristobal de las Casas. All clients have Spanish as their main language and, in case of simulating a rural group, each will additionally have one of the following languages: Tsotsil, Tseltal, Chol, Tojolabal, Zoque, or Mam.

If a group is urban, possible business are: floriculture, beans, coffee, maize, animal husbandry, fruits and vegetables, groceries, bakery, vehicle parts, leather shop, plastics, drinks, cheese, tortillas, antojitos, cereal, ice cream, candies, sausages, bread, dishes, chicken, dairy, tamales, fish, toasts, piñata, hammocks, handicraft, carpentry, catalogue, seamstress, cosmetics, shoes, clothing and beauty salon. Businesses categories help understanding of worked distribution: Personal care, Service, Art, Leisure, Food, Drink and Trade. There is literature suggesting more cooperation between clients with more similarities, this simulation only takes into account whether one person is tolerant towards the other and whether they share the same languages. Albeit there are inter-group exchanges regarding their social norms, there is little evidence to properly guide the modelling process in this sense. The extra individual properties allows for adapting how the simulation model is executes. Such experiments have not been conducted, as effectively it means adding extra compatibility hurdles between particular agents in terms of regarding their actions as desirable or undesirable.

Bibliography

Abbink, K., Irlenbusch, B., and Renner, E. (2006). Interest rates in group lending: A behavioural investigation. *Pacific Economic Review*, 11(2):185–199.

Ahlin, C. and Townsend, R. M. (February 2007). Using repayment data to test across models of joint liability lending. *The Economic Journal*, 117:F11–F51(41).

Ahn, T. K., Ostrom, E., and Walker, J. M. (2003). Heterogeneous preferences and collective action. *Public Choice*, 117(3-4):295–314.

Alam, S. J. (2008). *Understanding Social Complexity in the Context of HIV/AIDS: A Case Study in Rural South Africa*. PhD thesis, Manchester Met. University, Business School, Centre for Policy Modelling.

Alesina, A., Baqir, R., and Easterly, W. (1999). Public goods and ethnic divisions. *The Quarterly Journal of Economics*, 114(4):1243–1284.

Alesina, A. and Ferrara, E. L. (2000). Participation in heterogeneous communities. *The Quarterly Journal of Economics*, 115(3):847–904.

Allinson, G., Braidford, P., Houston, M., Robinson, F., and Stone, I. (2011). Business Support for Social Enterprises: Findings From a Longitudinal Study. Technical report, United Kingdom Department for Business Innovation and Skills.

Alter, S. K. (September 2002). Case studies in social enterprise. Technical report, Counterpart International Inc.

Anthony, D. (June 2005). Cooperation in microcredit borrowing groups: Identity, sanctions, and reciprocity in the production of collective goods. *American Sociological Review*, 70:496–515(20).

Armendariz, B. and Morduch, J. (June 2005). *The Economics of Microfinance*. MIT Press, Cambridge, United States, ISBN: 0262012162.

Austin, J. E. and Chu, M. (Fall 2006). Social Enterprise: Making a Difference, Business And Low-Income Sectors. *ReVista: Harvard Review of Latin America*, VI(1):1–3.

Axelrod, R. (2005). Advancing the art of simulation in the social sciences. In Rennard, J.-P., editor, *Handbook of Research on Nature Inspired Computing for Economy and Management*. Hersey.

Banerjee, A. and Somanathan, R. (2007). The political economy of public goods: Some evidence from India. *Journal of Development Economics*, 82(2):287–314.

Bankes, S. C. (May 2002). Agent-based modeling: a revolution? *Proceedings of the National Academy of Science U.S.A.*, 99 Supplement 3:7199–7200.

Banks, J., II, J. S. C., Nelson, B. L., and Nicol, D. M. (2009). *Discrete-Event System Simulation*. Prentice Hall, fifth edition.

Battle, C. (2009). Quantifying achievements to improve effectiveness in private sector development. *Enterprise Development and Microfinance*, 20(3):205–219.

Beck, K. A. (2000). *A decision making model of child abuse reporting*. PhD thesis, University of British Columbia.

Bernard, H. R. (2005). *Research Methods in Anthropology: Qualitative and Quantitative Approaches, Chapter 18: Data Analysis, Models and Matrices*. AltaMira Press, fourth edition.

Biggar, N. (September 2009). Measuring poverty outreach: how two different microfinance institutions used the progress out of poverty index. *Journal of Enterprise Development and Microfinance*, 20:177–187(11).

Boero, R. and Squazzoni, F. (2005). Does Empirical Embeddedness Matter? Methodological Issues on Agent-Based Models for Analytical Social Science. *Journal of Artificial Societies and Social Simulation (JASSS)*, 8(4):6.

Borgatta, E. F., editor (1991). *Encyclopedia of Sociology, Vol. 3*. Macmillan.

Borzaga, C., Defourny, J., Galera, G., Les, E., Nogales, R., Nyssens, M., and Spear, R. (2008a). Overview of the emergence and evolution of social enterprise. In *Social Enterprise: a New Model for Poverty Reduction and Employment Generation – an Examination of the Concept and Practice in Europe and The Commonwealth of Independent States*. United Nations Development Program (UNDP).

Borzaga, C., Defourny, J., Galera, G., Leś, E., and Nogales, R. (2008b). Initial Study on the Promotion of Social Enterprises. In Borzaga, C., Galera, G., and Nogales, R., editors, *Social Enterprise: A New Model for Poverty Reduction and Employment Generation*. United Nations Development Programme (UNDP) and L'Emergence de l'Enterprise Sociale (EMES).

Bouman, F. J. A. (1995). Rotating and accumulating savings and credit associations: A development perspective. *World Development*, 23(3):371–384.

Bousquet, F., Barreteau, O., Le Page, C., Mullon, C., and Weber, J. (1999). An environmental modelling approach: the use of multi-agent simulations. *Advances in environmental modelling*, pages 113–122.

Brau, J. C. and Woller, G. M. (2004). Microfinance: A comprehensive review of the existing literature. *Journal of Entrepreneurial Finance and Business Ventures*, 9(1):1–26.

Burlando, R. and Guala, F. (2005). Heterogeneous agents in public goods experiments. *Experimental Economics*, 8(1):35–54.

Burns, J. M. C. (2009). Middle range theory. In Mills, A. J., Durepos, G., and Wiebe, E., editors, *Encyclopedia of Case Study Research*. SAGE Publications.

Camerer, C. F. and Fehr, E. (2001). Measuring social norms and preferences using experimental games: A guide for social scientists. In Henrich, J., Boyd, R., Bowles, S., Camerer, C. F., Fehr, E., and Gintis, H., editors, *Foundations of human sociality: economic experiments and ethnographic evidence from fifteen small-scale societies*. Oxford University Press, New York.

Campion, A., Linder, C., and Knotts, K. (November 2008). Putting the Social Into Performance Management: A Practice-based Guide for Microfinance. Technical report, Imp-Act Consortium, Institute of Development Studies, University of Sussex. ISBN: 978 1 85864 547 6.

Carden, F. (2009). *Knowledge to Policy: Making the Most of Development Research*. Sage.

Carillo, N. R. (2010). Family and group ties in Microfinance activities: framed field experiments in Mexico. Master's thesis, Social Science Research Center, Technische Universität Berlin, Germany.

CGAP (2007). CGAP reflections on the Compartamos initial public offering: A case study on microfinance interest rates and profits. *International Web Conference*.

CGAP and EU/ACP (July 2008). Microfinance Technology Survey. Technical report, Consultive Group to Assist the Poor (CGAP), European Union-African, Caribbean and Pacific Microfinance Programme.

CGAP and FGV (February 2010). Branchless Banking Agents in Brazil: Building Viable Networks. Technical report, Fundação Getúlio Vargas (FGV), São Paulo, Brazil and Consultative Group to Assist the Poor (CGAP), Washington, D.C., United States, São Paulo, Brazil.

Charness, G. and Rabin, M. (2002). Understanding social preferences with simple tests. *The Quarterly Journal of Economics*, 117(3):817–869.

Chatfield, C. (2000). *Time-Series Forecasting*. Chapman and Hall, first edition.

Chiquiar, D. (June 2005). Why Mexico's regional income convergence broke down. *Journal of Development Economics*, 77(1):257–275.

Choi, B. K. and Kang, D. (2013). *Modeling and Simulation of Discrete Event Systems*. Wiley, first edition.

Churchill, C. (2007). Protecting the Poor: A Microinsurance Compendium. Technical report, International Labor Office (ILO) and Munich Re Foundation. ISBN: 9789221192541.

CIA (2008). Mexico, world factbook. Technical report, Central Intelligence Agency, United States.

Cicirelli, F., Furfaro, A., Giordano, A., and Nigro, L. (2009). Distributed simulation of repast models over hla/actors. In *DS-RT '09: Proceedings of the 2009 13th IEEE/ACM International Symposium on Distributed Simulation and Real Time Applications*, pages 184–191, Washington, United States. Institute of Electrical and Electronics Engineers IEEE.

Coleman, B. E. and Wynne-Williams, J. (2006). *Chapter 5: Household Savings in Rural finance in the Lao People's Democratic Republic: demand, supply, and sustainability: results of household and supplier surveys.* Asian Development Bank.

Coleman, J. (1998). *Foundations of Social Theory.* Harvard University Press.

Collins, D., Morduch, J., Rutherford, S., and Ruthven, O. (2009). *Portfolios of the Poor: How the World's Poor Live on $2 a Day.* Princeton University Press.

Conning, J. (1996). *Financial contracting and intermediary structures in a rural credit market in Chile: A theoretical and empirical analysis.* PhD thesis, Yale University.

Conte, R. and Paolucci, M. (2004). Responsibility for societies of agents. *Journal of Artificial Societies and Social Simulation (JASSS)*, 7(4).

Cook, C. W. (February, 2008). Mexico's drug cartels. Technical report, Open CRS RL34215, Congressional Research Reports for the People, Center for Democracy and Technology, Washington, United States.

Cornes, R. and Sandler, T. (1996). *The Theory of Externalities, Public Goods, and Club Goods.* Cambridge University Press, second edition.

Costa, D. L. and Kahn, M. E. (2003). Civic engagement and community heterogeneity: An economist's perspective. *Perspectives on Politics*, 1(01):103–111.

Creswell, J. W. and Clark, V. L. L. P. (2010). *Designing and Conducting Mixed Methods Research*. SAGE Publications, second edition.

Davister, C., Defourny, J., and Gregoire, O. (2004). Work integration social enterprises in the European Union: An overview of existing models. Technical report, L'Emergence de l'Enterprise Sociale (EMES) European Research Network.

De Oliveira, A., Croson, R. T. A., and Eckel, C. C. (2009). One Bad Apple: Uncertainty and Heterogeneity in Public Good Provision. *Social Science Research Network SSRN eLibrary*.

Defourny, J. and Nyssens, M. (2010). Conceptions of social enterprise and social entrepreneurship in europe and the united states: Convergences and divergences. *Journal of Social Entrepreneurship*, 1(1):32 – 53.

Dey, C. (2007). Developing silent and shadow accounts. In Jeffrey Unerman, J. B. and O'Dwyer, B., editors, *Sustainability accounting and accountability*. Routledge.

Doorenbos, R. B. (2001). Production matching for large learning systems. Technical report, Carnegie Mellon University, Pittsburgh, United States.

DTIUK (July 2002). Social Enterprise: a Strategy for Success. Technical report, Department of Trade and Industry United Kingdom (DTIUK).

Dunn, D. S. (2000). *Statistics and Data Analysis For Behavioral Sciences*. McGraw-Hill, first edition.

Easterly, W. (2000). Can institutions resolve ethnic conflict ? Policy Research Working Paper Series 2482, The World Bank.

Easterly, W. and Levine, R. (1997). Africa's growth tragedy: Policies and ethnic divisions. *The Quarterly Journal of Economics*, 112(4):1203–1250.

Edmonds, B. and Hales, D. (2003). Replication, replication and replication: Some hard lessons from model alignment. *Journal of Artificial Societies and Social Simulation (JASSS)*, 6(4).

Edmonds, B., Lucas, P., Rouchier, J., and Taylor, R. (2013). Human societies: Understanding observed social phenomena. In Edmonds, B. and Meyer, R., editors, *Simulating Social Complexity: A Handbook (Understanding Complex Systems)*. Springer.

Edmonds, B. and Moss, S. (2005). From KISS to KIDS an anti-simplistic modelling approach. In *Multi-Agent and Multi-Agent-Based Simulation*, volume 3415 of *Lecture Notes in Computer Science*, pages 130–144. Springer.

EMES and UNDP (April 2006). Case studies in social enterprise. Technical report, L'Emergence de l'Enterprise Sociale (EMES) European Research Network and United Nations Development Programme (UNDP), Bratislava Regional Center.

Epstein, J. M. (2006). *Generative Social Science: Studies in Agent-Based Computational Modeling (Princeton Studies in Complexity)*. Princeton University Press.

Fehr, E. and Fischbacher, U. (2002). Why social preferences matter – the impact of non-selfish motives on competition, cooperation and incentives. *Economic Journal*, 112(478):C1–C33.

Fischbacher, U. and Gachter, S. (2010). Social preferences, beliefs, and the dynamics of free riding in public goods experiments. *American Economic Review*, 100(1):541–56.

Foster, I. (1995). *Designing and Building Parallel Programs: Concepts and Tools for Parallel Software Engineering*. Addison-Wesley Longman Publishing, Boston, United States.

Frigg, R. and Reiss, J. (2011). The philosophy of simulation: hot new issues or same old stew? *Synthese*, 180(1):77.

Galán, J. M. and Izquierdo, L. R. (2005). Appearances can be deceiving: Lessons learned re-implementing axelrod's 'evolutionary approach to norms'. *Journal of Artificial Societies and Social Simulation (JASSS)*, 8(3):2.

Gash, M. (2012). Pathways to change. In Nelson, C., editor, *Savings Groups at the Frontier*. Practical Action, United Kingdom.

Gächter, S. (2010). Conditional cooperation: Behavioral regularities from the lab and the field and their policy implications. In Frey, B. S. and Stutzer, A., editors, *Economics and Psychology: A Promising New Cross-Disciplinary Field*. The MIT Press.

Geller, A., Goolsby, R., and Hoffer, L. (2010). On qualitative data in agent-based models. In *3rd World Congress on Social Simulation: Scientific Advances in Understanding Societal Processes and Dynamics*. University Of Kassel.

Geweke, J. (2005). *Contemporary Bayesian Econometrics and Statistics (Wiley Series in Probability and Statistics)*. Wiley-Interscience.

Ghatak, M. (July 2000). Screening by the Company You Keep: Joint Liability Lending and the Peer Selection Effect. *Economic Journal*, 110(465):601–31.

Ghatak, M. (November 2002). Exploiting Social Networks to Alleviate Credit Market Failures: On the Endogenous Selection of Peer Groups in Microfinance Programs. Technical report, University of California, Conference on Credit, Trust, Calculation.

Ghatak, M. (October 1999). Group lending, local information and peer selection. *Journal of Development Economics*, 60:27–50(24).

Gilbert, N. (2007). *Agent-Based Models (Quantitative Applications in the Social Sciences)*. Sage, annotated edition.

Gilbert, N., editor (2008). *Researching Social Life*. SAGE Publications.

Gilbert, N. (March 2009). A personal introduction. In *Association for the Advancement of Artificial Intelligence (AAAI) Spring Symposium on Technosocial Predictive Analytics*, Stanford University, California, United States.

Gilbert, N. and Conte, R. (1995). *Artificial Societies: The Computer Simulation Of Social Life (Social Research Techniques & Methods)*. Routledge.

Gilbert, N. and Troitzsch, K. (2005). *Simulation for the Social Scientist (Second Edition)*. Open University Press.

Gine, X., Jakiela, P., Karlan, D., and Morduch, J. (2010). Microfinance games. *American Economic Journal: Applied Economics*, 2(3):60–95.

Given, L. M., editor (2008). *Encyclopaedia of Qualitative Research Methods*. SAGE Publications.

Gladwin, C. H., editor (1989). *Ethnographic Decision Tree Modeling (Qualitative Research Methods)*. SAGE Publications.

Goldberg, M., Bowles, S., and Miller, J. (2004). To Get That Little: A Computational Model of Microfinance. Technical report, Santa Fe Institute.

Gomez, R. and Santor, E. (2001). Membership has its privileges: the effect of social capital and neighbourhood characteristics on the earnings of microfinance borrowers. *Canadian Journal of Economics/Revue canadienne d'économique*, 34(4):943–966.

Grameen Bank (February 2010). Grameen Bank At a Glance. Technical report, Grameen Bank.

Greene, W. H. (2011). *Econometric Analysis*. Prentice Hall, seventh edition.

Grimm, V., Berger, U., DeAngelis, D. L., Polhill, J. G., Giske, J., and Railsback, S. F. (2010). The {ODD} protocol: A review and first update. *Ecological Modelling*, 221(23):2760 – 2768.

Guala, F. (1998). Experiments as mediators in the non-laboratory sciences. *Philosophica*, 62.

Guala, F. (2005). *The Methodology of Experimental Economics*. Cambridge University Press.

Guala, F. and Salanti, A. (2001). Theory, experiments, and explanation in economics. *Revue internationale de philosophie*, v.(217):327 – 349.

Guttman, J. M. (March 2007). Repayment Performance in Microcredit Programs: Theory and Evidence. Technical report, Indiana State University.

Gächter, S. and Thöni, C. (2005). Social learning and voluntary cooperation among like-minded people. *Journal of the European Economic Association*, 3(2-3):303–314.

Hanneman, R. (1988). *Computer-Assisted Theory Building: Modeling Dynamic Social Systems*. SAGE Publications.

Hardin, G. (1968). The tragedy of the commons. *Science*, 162(3859):1243–1248.

Harper, M. (2002). Self-help groups and grameen bank groups: What are the differences? In *Beyond Micro-credit: Putting Development Back into Micro-finance*. Oxfam.

Heckman, J. J. and Vytlacil, E. J. (2007). Econometric evaluation of social programs, part i: Causal models, structural models and econometric policy evaluation. In Heckman, J. and Leamer, E., editors, *Handbook of Econometrics*, volume 6 of *Handbook of Econometrics*, chapter 70. Elsevier.

Helms, B. (2006). Access for All: Building Inclusive Financial Systems. Technical report, World Bank and Consultative Group to Assist the Poor. ISBN: 9780821363607.

Henrich, J. and et al. (2001). In search of homo economicus: Behavioral experiments in 15 small-scale societies. *American Economic Review*, 91(2):73–78.

Hermes, N. and Lensink, R. (2007). The empirics of microfinance: what do we know? *Economic Journal*, 117(517):F1–F10.

Hermes, N., Lensink, R., and Mehrteab, H. T. (2005). Peer monitoring, social ties and moral hazard in group lending programs: Evidence from eritrea. *World Development*, 33(1):149 – 169.

Hirsch, G., Rosengard, J., Stuart, G., and Johnston, D. (July 2005). SymBancTM: A Simulator for Microfinance Institutions. *International Conference of the System Dynamics Society*.

Hirsch, G. B., Rosengard, J. K., Stuart, G., and Don E. Johnston, J. (November 2004). Users' Guide to the KSG Micro Finance Institutions Simulator, SymBancTMV.1. Technical report, Harvard University, John F. Kennedy School of Government.

Hoekstra, R. C., Arkel, H. v., and Leurs, B. (2007). Modeling local monetary flows in poor regions: A research setup to simulate the multiplier effect in local economies. *Interdisciplinary Description of Complex Systems - scientific journal*, 5(2):138–150.

ILO (March 2002). Microfinance for employment creation and enterprise development. Technical report, International Labour Office, Committee on Employment and Social Policy.

Islam, N. (2009). Can Microfinance Reduce Economic Insecurity and Poverty? By How Much and How? Technical report, United Nations, Department of Economics and Social Affairs.

Ito, S. (August 2003). Microfinance and Social Capital: Does Social Capital Help Create Good Practice? *Development in Practice*, 13(4):322–332.

Johnson, S. (2009). Quantifying achievements in private sector development. Technical report, University of Bath, Centre For Development Studies, Working Paper.

Jones, N., Jones, H., and Walsh, C. (August 2008). Political science? strengthening science–policy dialogue in developing countries. Working paper 294, Overseas Development Institute, London, England.

Karlan, D., Harigaya, T., and Nadel, S. (2009). Evaluating microfinance program innovation with randomized controlled trials: Examples from business training and group versus individual liability. In Watkins, T. A. and Hicks, K., editors, *Moving Beyond Storytelling: Emerging Research in Microfinance (Contemporary Studies in Economic and Financial Analysis, Volume 92)*. Emerald Group.

Karlan, D. S. (2001). Microfinance impact assessments: The perils of using new members as a control group. *Journal of Microfinance*, 3:76–85.

Karlan, D. S. (February 2007). Social connections and group banking. *Economic Journal*, 117:F52–F84(1).

Keuzenkamp, H. A. (2006). *Probability, Econometrics and Truth: The Methodology of Econometrics*. Cambridge University Press.

Klarsfeld, L., Lepicard, F., and Hystra (2012.). *Leveraging information and communication technology for the base of the pyramid:*. Hystra, [s.l.] :. Available online.

Kuorikoski, J. (2010). *Society by Numbers: Studies on Model-based Explanations in the Social Sciences*. PhD thesis, University of Helsinki, Department of Philosophy.

Labaree, D. F. (1997). Public goods, private goods: The american struggle over educational goals. *American Educational Research Journal*, 34(1):39–81.

Ledgerwood, J. (March 2001). *Microfinance Handbook: An Institutional and Financial Perspective (Sustainable Banking With the Poor)*. World Bank.

Ledgerwood, J., Earne, J., and Nelson, C., editors (2013). *The New Microfinance Handbook: A Financial Market System Perspective*. World Bank Publications.

Lehtinen, A. and Kuorikoski, J. (2007). Computing the perfect model: Why do economists shun simulation? *Philosophy of Science*, 74(3):304–329.

Lucas, P. (2011). Usefulness of simulating social phenomena: evidence. *Artificial Intelligence and Society*, pages 1–8. 10.1007/s00146-010-0315-1.

Lucas, P. (2014). An adaptation of the ethnographic decision tree modeling methodology for developing evidence-driven agent-based models. In Kamiński, B. and Koloch, G., editors, *Advances in Social Simulation*, volume 229 of *Advances in Intelligent Systems and Computing*, pages 343–350. Springer.

Lucas, P. (January 2010). Modelling the microfinance case study. emil-t (emergence in the loop: simulating the two way dynamics of norm innovation). Technical report, Centre For Policy Modelling, Manchester Met. University, Manchester, England.

Lucas, P. (July 2009a). Final data compilation. Technical report, Centre For Policy Modelling, Manchester Met. University and Chair of Sociology, in particular of Modeling and Simulation, Eidgenössische Technische Hochschule, England and Switzerland.

Lucas, P. (March 2009b). Relating financial characterisation of microfinance groups and their conventional social behaviour. Technical report, Centre For Policy Modelling, Manchester Met. University and Chair of Sociology, in particular of Modeling and Simulation, Eidgenössische Technische Hochschule, England and Switzerland.

Lucas, P. (September 2007). Aabss: Affective agent-based social simulation –a critique of models of primate-like social behaviour. Master's thesis, (MPhil) at the School of Mathematics and Computer Science, Heriot-Watt University, Edinburgh, Scotland.

Lucas, P., Banuri, S., and de Oliveira, A. (2014.). The effects of group composition and social preference heterogeneity in a public goods game: An agent-based simulation. *Journal of Artificial Societies and Social Simulation (JASSS)*.

Lucas, P., Morales, F., and García, I. (June 2008). First fieldwork report: Social conventions and dynamic of solidarity groups - an experience in chiapas. Technical report, Centre For Policy Modelling, Manchester Met. University, Chair of Sociology, in particular of Modeling and Simulation, Eidgenössische Technische Hochschule and PROIMMSE-IIA, Mexico National Autonomous University, England, Switzerland and Mexico.

Lucas, P. and Payne, D. (2014). Usefulness of agent-based simulation in testing collective decision-making models. In Adamatti, D., Dimuro, G., and Coelho, H., editors, *Interdisciplinary Applications of Agent-Based Social Simulation and Modeling*. IGI.

Luck, M., McBurney, P., Shehory, O., and Willmott, S. (2005). *Agent Technology: Computing as Interaction (A Roadmap for Agent Based Computing)*. AgentLink.

Lunde, S. A., Sheldon, T., and Waterfield, C. (December 2006). Using microfin 4, a handbook for operational planning and financial modeling. Technical report, Consultative Group to Assist the Poor (CGAP).

Lyman, T. (October 2009). Market overview: Technology for microfinance - trends driving the technology, publishing supplement. Technical report, International Banking Systems.

Lysenko, M. and D'Souza, R. M. (2008). A framework for megascale agent based model simulations on graphics processing units. *Journal of Artificial Societies and Social Simulation (JASSS)*, 11(4):10.

Mader, P. (2011a). Attempting the production of public goods through microfinance. *Journal of Infrastructure Development*, 3(2):153–170.

Mader, P. (2011b). Making the poor pay for public goods via microfinance: Economic and political pitfalls in the case of water and sanitation. Technical Report 11/14, Max Planck Institute for the Study of Societies, Köln.

Maindonald, J. and Braun, W. J. (2010). *Data Analysis and Graphics Using R: An Example-Based Approach (Cambridge Series in Statistical and Probabilistic Mathematics)*. Cambridge University Press, third edition.

Martey, R. M. and Stromer-Galley, J. (2007). The Digital Dollhouse: Context and Social Norms in The Sims Online. *Games and Culture*, 2(4):314–334.

Mas, I. (April 2009). The Economics of Branchless Banking. *Innovations: Technology, Governance, Globalization*, 4(2):57–75.

Mas, I. and Morawczynski, O. (2009). Designing mobile money services lessons from m-pesa. *Innovations: Technology, Governance, Globalization*, 4(2):77–91.

Mauro, P. (1995). Corruption and growth. *The Quarterly Journal of Economics*, 110(3):681–712.

Mauthner, D. M., Birch, M., Jessop, J., and Miller, T., editors (2002). *Ethics in Qualitative Research*. Sage, first edition.

Meadows, D. H., Randers, J., Meadows, D. L., and Behrens, W. W. (1974). *The Limits to growth: A report for the Club of Rome's Project on the Predicament of Mankind*. Universe Books, second edition.

Menard, S. (2001). *Applied Logistic Regression Analysis (Quantitative Applications in the Social Sciences)*. SAGE Publications, second edition.

Menard, S., editor (2007). *Handbook of Longitudinal Research: Design, Measurement, and Analysis*. Academic Press, first edition.

Merton, R. K. (1967). *On Theoretical Sociology*. Free Press.

microLINKS and USAID (2010). The Impacts of Social Norms on Value Chain Performance. Technical report, Microenterprise Learning Information and Knowledge Sharing (microLINKS) and United States Agency for International Development (USAID).

Miguel, E. (2004). Tribe or nation? nation building and public goods in kenya versus tanzania. *World Politics*, 56(03):328–362.

Miguel, E. and Gugerty, M. K. (2005). Ethnic diversity, social sanctions, and public goods in kenya. *Journal of Public Economics*, 89(11-12):2325–2368.

MIX (August 2010). Regional Benchmarks: Latin America and the Caribbean. Technical report, Microfinance Information eXchange (MIX).

MIX (December 2009). Microbanking Bulletin Number 19. Technical report, Microfinance Information eXchange (MIX).

MIX (Spring 2007). Challenging Perspectives in Microfinance, Microbanking Bulletin Number 14. Technical report, Microfinance Information eXchange (MIX).

Morawczynski, O. (2009). Examining the usage and impact of transformational M-Banking in kenya. In Aykin, N., editor, *Internationalization, Design and Global Development*, volume 5623 of *Lecture Notes in Computer Science*, pages 495–504. Springer. 10.1007/978-3-642-02767-3_55.

Morawczynski, O. and Pickens, M. (August 2009). Poor people using mobile financial services: Observations on customer usage and impact from m-pesa. Technical report, Consultative Group to Assist the Poor (CGAP).

Moss, S. (2008). Alternative approaches to the empirical validation of agent-based models. *Journal of Artificial Societies and Social Simulation (JASSS)*, 11(1):5.

Moss, S. and Edmonds, B. (2005). Sociology and simulation: Statistical and qualitative cross-validation. *American Journal of Sociology*, 110:1095–1131.

Mukhopadhyay, J. P. (December 2007). Integrating the Poorest into Microfinance: An Impact Assessment. *Centre For Microfinance, Eye On Microfinance Issue #6, Chennai, India.*

Murray, R., Caulier-Grice, J., and Mulgan, G. (2010). *The Open Book of Social Innovation: Ways to Design, Develop and Grow Social Innovation.* United Kingdom National Endowment for Science, Technology and the Arts (NESTA).

Mäki, U. (2005). Models are experiments, experiments are models. *Journal of Economic Methodology*, 12(2):303–315.

Olson, M. (1971). *The Logic of Collective Action: Public Goods and the Theory of Groups, Second printing with new preface and appendix (Harvard Economic Studies).* Harvard University Press, revised edition.

Omwansa, T. (February 2009). M-PESA: Progress and Prospects. Technical report, GSMA Mobile World Congress, innovations MIT Press.

Palier, J. (2004). Defining the concept of empowerment through experiences in India. In *Microfinance challenges : empowerment or disempowerment of the poor?*, number 10, pages 35–53. Institut Français de Pondichéry IFP.

Paxton, J. and Thraen, C. (2003). An application of mean-covariance structure models for the analysis of group lending behavior. *Journal of Policy Modeling*, 25(9):863 – 868.

Pearce, C. (2009). *Communities of Play: Emergent Cultures in Multiplayer Games and Virtual Worlds.* The MIT Press.

Pedhazur, E. J. (1982). *Multiple Regression in Behavioral Research: Explanation and Prediction.* Harcourt College, second edition.

Pedhazur, E. J. and Schmelkin, L. P. (1991). *Measurement, Design, and Analysis: An Integrated Approach*. Psychology Press, student edition.

Pohjola, M. (2003). The adoption and diffusion of ICT across countries: Patterns and determinants. In Jones, D., editor, *New Economy Handbook*, pages 77–100. Elsevier.

Polhill, J. G. (2010). Odd updated. *Journal of Artificial Societies and Social Simulation (JASSS)*, 13(4):9.

Rajeev, M., Ranade, R., and Deb, S. (July 2006). Why do poor farmers default less?: Case of Indian informal credit market a game theoretic exploration. Technical report, MPRA Paper 768, University Library of Munich, Germany.

Rashid, S., Yoon, Y., and Kashem, S. B. (2011). Assessing the potential impact of Microfinance with agent-based modeling. *Economic Modelling*, 28(4):1907 – 1913.

Ravallion, M., Chen, S., and Sangraula, P. (2009). Dollar a day revisited. *World Bank Economic Review*, 23(2):163–184.

Remondino, M. (2004). *Analysis of Agent Based Paradigms for Complex Social Systems Simulation*. PhD thesis, University of Turin.

Richmond, P., Walker, D., Coakley, S., and Romano, D. (2010a). High performance cellular level agent-based simulation with flame for the gpu. *Briefings in bioinformatics*, 11(3):334–347.

Richmond, P., Walker, D., Coakley, S., and Romano, D. (2010b). High performance cellular level agent-based simulation with FLAME for the GPU. *Brief Bioinform*.

Ritzema, T. and Harris, B. (2008). The use of second life for distance education. *Journal of Computing Sciences in Colleges*, 23(6):110–116.

Robinson, M. S. (2001). *The Microfinance Revolution: Sustainable Finance for the Poor*. World Bank.

Rodriguez Meza, J. (2000). *Group and Individual Microcredit Contracts: a Dynamic Numerical Analysis*. PhD thesis, Ohio State University.

Rosenberg, R. (June 2007). Consultative Group to Assist the Poor (CGAP) Reflections on the Compartamos Initial Public Offering: A Case Study on Microfinance Interest Rates and Profits. Technical report, Consultive Group to Assist the Poor (CGAP) Focus Note 42. Washington DC. , United States.

Rosenberg, R., Gonzalex, A., and Narain, S. (February 2009). The new moneylenders: Are the poor being exploited by high microcredit interest rates? Occasional paper, Consultive Group to Assist the Poor (CGAP).

Rowell, D. and Wormley, D. N. (1996). *Introduction to System Dynamics*. Prentice Hall, first edition.

Roy, P. V. and Haridi, S. (2004). *Concepts, Techniques, and Models of Computer Programming*. MIT Press, Cambridge, United States.

Rutherford, S. and Arora, S. S. (2011). *The Poor and Their Money: Microfinance From a Twenty-First Century Consumers Perspective*. Practical Action, second edition.

Sanders, J. M. and Nee, V. (1996). Immigrant Self-Employment: The family as social capital and the value of human capital. *American Sociological Review*, 61(2):231–249.

Sarkar, S. (2013). *Scientific Models in Philosophy of Science: An Encyclopaedia*. Routledge, second edition.

Schreiner, M. (August 2009). Progress out of Poverty Index: A Simple Poverty Scorecard for Mexico. Technical report, Grameen and Ford Foundation.

Schreiner, M., Correa, M., Díaz, J. A., Escobar, A., and Mercedes, M. (2002). Scoring: The next breakthrough in microcredit? Technical report, Consultative Group to Assist the Poorest.

Segone, M., editor (2008). *Bridging the Gap: The role of monitoring and evaluation in evidence-based policy making*. United Nations Children's Fund UNICEF.

SEUK (2013). State of social enterprise survey. Technical report, Social Enterprise UK.

Shafik, N. (1994). Economic development and environmental quality: An econometric analysis. *Oxford Economic Papers*, 46(0):757–73.

Shapiro, I. (2007). *The Flight from Reality in the Human Sciences*. Princeton University Press.

Sharma, M. and Zeller, M. (1997). Repayment performance in group-based credit programs in bangladesh: An empirical analysis. *World Development*, 25(10):1731–1742.

Shipton, P. M. (2007). *The Nature of Entrustment: Intimacy, Exchange, and the Sacred in Africa (Yale Agrarian Studies Series)*. Yale University Press.

Sinha, F. (2006). Social Rating and Social Performance Reporting in Microfinance, Towards a Common Framework. Technical report, Micro-Credit Ratings International Limited, Argidius Foundation, Small Enterprise Education and Promotion Network (SEEP).

Squazzoni, F. (2012). *Agent-Based Computational Sociology*. Wiley, first edition.

Squire, L. (1993). Fighting poverty. *American Economic Review*, 83(2):377–82.

Srinivasan, T. N. (September 2004). Dollar a day - how much does it say? Poverty in focus, International Policy Centre for Inclusive Growth, United Nations Development Programme (UNDP). Number: 4, Editor: Alejandro Grinspun.

Stiglitz, J. E. (1990). Peer Monitoring and Credit Markets. *World Bank Economic Review*, 4(3):351–366.

Suarez, E. D., Casta nón-Puga, M., and Marquez, B. Y. (2009). Analyzing the Mexican microfinance industry using multi-level multi-agent systems. In *SpringSim '09: Proceedings of the 2009 Spring Simulation Multiconference*, pages 1–4, San Diego, United States. Society for Computer Simulation International.

Swan, L. S. (2009). Synthesizing insight: artificial life as thought experimentation in biology. *Biology and Philosophy*, 24(5):687–701.

Swidler, A. (1995). Cultural power and social movements. In Johnston, H. and Klandermans, B., editors, *Social Movements and Culture*, chapter 2. University of Minnesota Press.

Taleb, N. N. (April 2007). *The Black Swan: The Impact of the Highly Improbable.* Random House, ISBN: 1400063515.

Tesfatsion, L. and Judd, K. L., editors (2006). *Handbook of Computational Economics, Volume 2: Agent-Based Computational Economics.* North Holland, first edition.

Theodorson, G. and Theodorson, A. (1969). *A modern dictionary of sociology.* Apollo Eds. Crowell.

Timothy, B. and Maitreesh, G. (2006). Public goods and economic development. In Banerjee, A. V., Benabou, R., and Mookherjee, D., editors, *Understanding Poverty*. Oxford University Press.

Townsend, P. (December 2006). What is poverty? A historical perspective. *Poverty In Focus, Issue 9, International Poverty Centre, United Nations Development Programme (UNDP)*.

UNITAR (March 2013). Fundamentals of microfinance. Technical report, United Nations Institute For Training and Research (UNITAR).

United Nations (2006). *Building Inclusive Financial Sectors for Development*. United Nations, Publication No.: E.06.II.A.3, ISBN: 92-1-204251-1.

United Nations (2010). The Millennium Development Goals. Technical report, Department of Economic and Social Affairs of the United Nations Secretariat.

USAID (February 2008). Manual for the implementation of USAID poverty assessment tools. Technical report, United States Agency for International Development (USAID).

Van Bastelaer, T. (February 2000). Does social capital facilitate the poor's access to credit?: A review of the microeconomic literatutre (Social capital initiative working paper). Technical report, World Bank.

Vigdor, J. L. (2004). Community composition and collective action: Analyzing initial mail response to the 2000 census. *The Review of Economics and Statistics*, 86(1):303–312.

Vogelgesang, U. (2007). *Essays on Access to Financial Institutions, Inequality, and Redistribution*. AV Akademikerverlag.

Wallace, R. A. and Wolf, A. (2005). *Contemporary Sociological Theory: Expanding the Classical Tradition*. Pearson, sixth edition.

Waterfield, C. and Sheldon, T. (2004). Microfin: A Financial Modeling Tool for Microfinance Institutions. Technical report, Microfin and Consultative Group to Assist the Poor (CGAP).

WEF (2010). Global Risks 2010. Technical report, World Economic Forum (WEF).

Westall, A. (2009). Business or third sector? what are the dimensions and implications of researching and conceptualising the overlap between business and third sector? Working paper, University of Birmingham.

WHO and FAO (2003). *Diet, nutrition and the prevention of chronic diseases: Expert Consultation*. World Health Organization (WHO) and Food and Agriculture Organization (FAO), Geneva, Switzerland.

Wilson, W. J. and Chaddha, A. (2009). The role of theory in ethnographic research. *Ethnography*, 10(4):549–564.

Wolkenhauer, O. (2001). *Data Engineering: Fuzzy Mathematics in Systems Theory and Data Analysis*. Wiley-Interscience, first edition.

Woolcock, M. J. V. (1999). Learning from failures in microfinance: What unsuccessful cases tell us about how group-based programs work. *American Journal of Economics and Sociology*, 58(1):pp. 17–42.

World Bank (1990). *World Development Report 1990*. Oxford University Press.

World Bank (2005). Mexico: Income generation and social protection for the poor, volume 1: Integrated executive summary. Technical report, World Bank.

Wydick, B. (1999). Can social cohesion be harnessed to repair market failures? evidence from group lending in guatemala. *The Economic Journal*, 109(457):pp. 463–475.

Yoshioka, H. (December 2006). A q-analysis of census data: Intra-household income allocation and school attendance in chiapas, Mexico. *Quality and Quantity*, 40:1061–1077(17).

Young, J. and Mendizabal, E. (September 2009). Helping researchers become policy entrepreneurs – how to develop engagement strategies for evidence-based policy-making. Briefing paper, Overseas Development Institute, London, England.

Yunus, M. (July 2007). Remarks by Muhammad Yunus, Managing Director, Grameen Bank. Technical report, Microcredit Summit. Vol.: 5, No.: 1.

Zeller, M. (1998). Determinants of Repayment Performance in Credit Group: The Role of Program Design, Intragroup Risk Pooling, and Social Cohesion. *Economic Development and Cultural Change*, 46(3):599–620.

Zeller, M., Lapenu, C., and Greely, M. (October 2003). Measuring social performance of micro-finance institutions: a proposal (final report). Technical report, Argidius Foundation and Consultative Group to Assist the Poor (CGAP), Social Performance Indicators Initiative (SPI).

Zhang, W.-B. (2006). *Discrete Dynamical Systems, Bifurcations and Chaos in Economics, Volume 204 (Mathematics in Science and Engineering)*. Elsevier Science.

Ören, T. I. (2002). Rationale for a code of professional ethics for simulationists. *Summer Computer Simulation Conference*, pages 428–433.

Ören, T. I., Elzas, M. S., Smit, I., and Birta, L. G. (2002). A code of professional ethics for simulationists. *Summer Computer Simulation Conference*, pages 428–433.